MESSIER 8 AND 20

Sky and TELESCOPE



CHARLES A. FEDERER, JR.—*Editor* HELEN SPENCE FEDERER—*Managing Editor*



## The Editors Note . . .

**INEVITABLY, the war is changing the activities of amateur astronomers. Dimouts and blackouts encourage constellation study and telescope use, while difficulties in getting materials make a would-be telescope maker turn to observing. In line with this trend, our pages for constellation study and for observers will be augmented from time to time. On page 23 appears the first in a series of lists of double stars for amateur telescopes. Subscribers are invited to make their observing requirements and other suggestions known.**

**The war is affecting our publication, as well. Difficulties of communication and transportation, rising costs, and other factors, have required changes in make-up and the use of space, most of which will begin with the July issue. At the same time, we change our printer to one who is closer to our headquarters. For the past two and a half years, The Little Print has been essential to our existence, by keeping its charges at a minimum and by cooperation in innumerable other details.**

**During this same period, and without remuneration, Earle B. Brown has been our invaluable accountant. He is the same well-known amateur astronomer who conducts our "Gleanings for A.T.M.s," and until recently, the class in advanced astronomy for the New York A.A.A. He was married a few weeks ago, drafted, deferred, and finally inducted into the Army on May 11th. Who will fill all his jobs, including that of a chief executive in the fast-expanding Mogey optical shop at Plainfield, N. J., which is filling government orders, we do not know.**

VOL. I, No. 8 **CONTENTS** JUNE, 1942

**COVER:** In Sagittarius, where the equator of the Milky Way crosses the ecliptic close to the winter solstice (which is on the meridian about midnight in June), lie two striking gaseous nebulae, here shown in the same field. The Trifid nebula (M20) is just north of the ecliptic; in the photograph it appears above the Lagoon nebula (M8), which is south of the ecliptic. These nebulae lie in a region containing a great deal of obscuring nebulosity, which may indicate that they are but illuminated parts of an extensive nebulous region. Two open clusters are to be noted, one well within the boundaries of M8, and the other less than a degree north and east of the Trifid. The photograph is from one of the last long-exposure plates made with the Bruce telescope before the Boyden station of Harvard Observatory was transferred from Arequipa, Peru, to Bloemfontein, South Africa. Exposure, four hours; scale, one millimeter is one minute of arc. Engraving from H. C. O. **Tercentenary Papers**, No. 12.



**BACK COVER:** The Sombrero nebula, N.G.C. 4594, photographed with the Mt. Wilson 60-inch reflector, May 3, 1916, exposure, 2¼ hours. This is an edgewise spiral galaxy, with a large amount of obscuring matter in its equatorial plane. (See "The Starry Heavens in June," page 26.)

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# THE PLANETS
## and their relation to history

By William H. Barton, Jr.

Numbers have always possessed a strange fascination. Their curious properties have intrigued students through the ages. Some of these characteristics are real and others are purely imaginary. Seven has been a "lucky" number from time unrecorded, just as 13 is "unlucky." Imagine the reactions of the old astronomers when they counted seven stars that were not "fixed." There were the sun, the moon, Mercury, Venus, Mars, Jupiter, and Saturn. These wanderers (*planetes,* to the Greeks) offered material for thought and observation. There was a great deal of misunderstanding about them, but, as time went on, their importance and significance increased.

These strange "stars" were deified and were supposed by many to exert influences on the earth and they that dwell thereon, a belief that even today is unfortunately not without its adherents. The Babylonians pursued study of the planets for astro-

*Nowhere can the motions of the planets, which were so puzzling to the ancients, be more dramatically and convincingly reproduced than by a projection planetarium. Here and in the Hayden Planetarium this month, the planets are discussed.*

**From a painting by D. Owen Stephens, "Nine Planets and a Million Suns."**

| Hour | 1st day | 2nd day | 3rd day | 4th day | 5th day | 6th day | 7th day |
|---|---|---|---|---|---|---|---|
| 1 | Saturn | Sun | Moon | Mars | Mercury | Jupiter | Venus |
| 2 | Jupiter | Venus | Saturn | Sun | Moon | Mars | Mercury |
| 3 | Mars | Mercury | Jupiter | Venus | Saturn | Sun | Moon |
| 4 | Sun | Moon | Mars | Mercury | Jupiter | Venus | — |
| 5 | Venus | Saturn | Sun | Moon | Mars | — | — |
| 6 | Mercury | Jupiter | Venus | Saturn | — | — | — |
| 7 | Moon | Mars | Mercury | — | — | — | — |
| 8 | Saturn | Sun | — | — | — | — | — |
| 9 | Jupiter | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — |
| 23 | Jupiter | Venus | Saturn | Sun | Moon | Mars | Mercury |
| 24 | Mars | Mercury | Jupiter | Venus | Saturn | Sun | Moon |

logical reasons. They believed that each planet exerted an influence on the different hours of the day. We know they were wrong, but they at least tried to play fair by devoting the hours impartially in turn to the seven planetary deities. You can imagine a table drawn up as above, with the planets in their supposed order from the earth.

This list is then repeated for the next period of seven days—each week. The days then came to be known by the name of the first hour: Saturn day, Sun day, Moon day, Mars day, Mercury day, Jupiter day, Venus day.

The Romans adopted days similarly named in Latin: Dies Saturni, Dies Solis, Dies Lunae, Dies Martis, Dies Mercurii, Dies Jovis, Dies Veneris.

From these names the Romance languages adopted their own names, that, with few exceptions, are very similar. In French, for instance, moving Sunday to the first in the list, as is now common practice, we have: Dimanche, Lundi, Mardi, Mercredi, Jeudi, Vendredi, Samedi.

**Aristarchus of Samos flourished about 280-264 B.C.**

The names in English are still dependent upon the name of ancient deities, but are dependent mainly upon those of Saxon origin rather than Latin:

| | |
|---|---|
| Sunday | Sunnan-daeg |
| Monday | Monan-daeg |
| Tuesday | Tues-daeg |
| Wednesday | Wodens-daeg |
| Thursday | Thors-daeg |
| Friday | Friga-daeg |
| Saturday | Saeter-daeg |

At the beginning of astronomical history these wandering stars were puzzling objects in the sky. Two of them (Mercury and Venus) always appeared near the sun, shining in the twilight after sunset and in the dawn before sunrise—never at midnight. The others were seen at various hours of the night. They constantly shifted among the stars, not always going in one direction, but sometimes pausing and retracing their steps and hurrying then as if to catch up with the parade. And all the while there was no suspicion that our earth was one of them, sharing in their motions—and in fact complicating their motions by its very own, at least for an observer on the earth.

Various mechanisms were proposed to account for these strange motions, and two such "systems" are well known, the Ptolemaic and the Copernican. It was only natural that the early philosophers should rather strongly adhere to the notion that the earth was some special sort of body and that it was the center of the universe. A few, on the other hand, dis-

sented from this geocentric (fundamentally egocentric) system. Aristarchus of Samos, more than 2,200 years ago, developed a system in which the earth and the other planets revolved around the sun. Hipparchus, who lived a century later, taught the other theory—that the universe circled around the earth. Ptolemy chose the wrong theory. But the means were not at hand then to discover the truth, and it was to be many centuries before the real nature of the solar system was to be revealed.

For 1,400 years this erroneous notion of the earth's place in the scheme of things was held as correct. Then Copernicus, a Polish monk, suggested that the motions of the heavenly bodies could be more easily accounted for if the earth were imagined circling the sun along with the other planets. He even predicted that the planets Mercury and Venus, both nearer the sun than the earth, would display phases like the moon. Fifty years later Galileo saw Venus display the changes that Copernicus had predicted.

The logic of Copernicus attracted the attention of Kepler, a mathematical astronomer, who attempted to account for the speeds and distances of the planets. The results of his many years of trial and error in analyzing the observations of his predecessor, Tycho Brahe, led him to conclude that:

1. Each planet moves in an ellipse which has the sun at one of its foci.

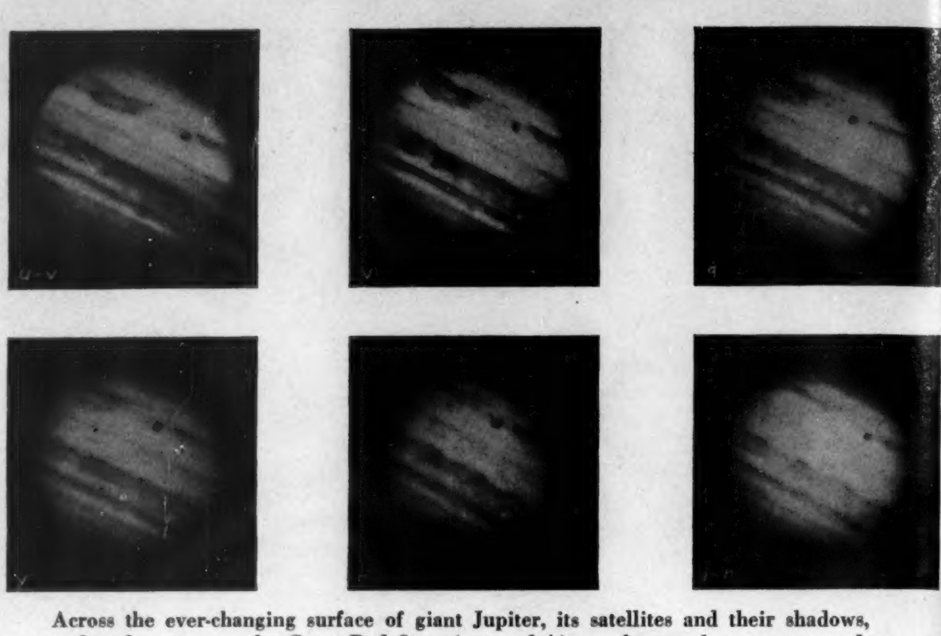
2. The radius vector of each planet passes over equal areas in equal intervals of time.

3. The cubes of the mean distances of any two planets from the sun are to each other as the squares of their periodic times.

These are called Kepler's laws of planetary motion. Their author did not know why they were true. He merely found that they fitted a mass of observed data, and his contribution was made. That was during the early part of the 17th century, when the telescope was beginning to make itself a factor in extending celestial horizons. Moreover, Kepler's work was followed in 1643—just 300 years ago—by the birth of the man who, in the latter part of the century, did discover the reasons for this Keplerian behavior. Sir Isaac Newton, writing his universal law of gravitation, told why the planets moved as Kepler's laws described.

Kepler's third law furnishes the means for finding the proportions of the solar system, but not the scale. He could figure the distances of the planets from the sun only in terms of the earth's distance—in astronomical units, as the astronomer says. But how long is the astronomical unit? That's another matter.

A peculiar relation between the planetary distances was announced in 1772 by the German astronomer, Johann Ehlert Bode. It was not original with him but had been previously discovered by Johann Titius, and, according to John Herschel, by Voiron, who was mathematics professor at the Prytanée Militaire.



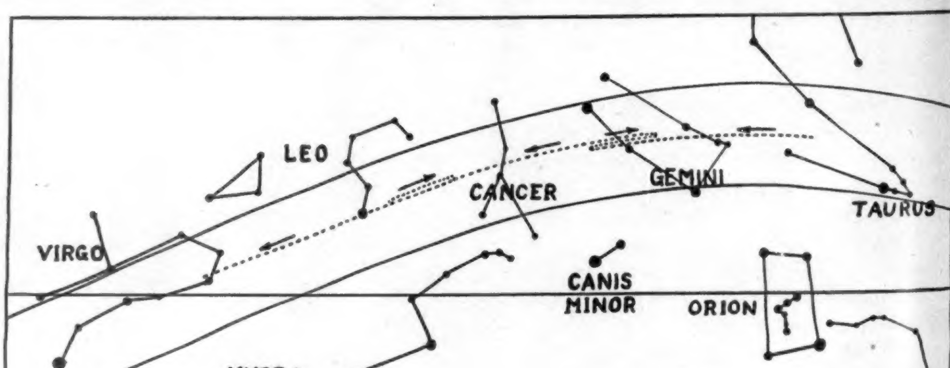
**Across the ever-changing surface of giant Jupiter, its satellites and their shadows, and such storms as the Great Red Spot (*upper left*) are frequently seen to travel.**

Anyway, it is called Bode's law. Set down a series of 4's and against them 0, 3, 6, 12, 24, and so on. Add each pair and divide by 10. The results are the distances of most planets from the sun in terms of the earth's distance. Thus:

| *Planet* | | | *Sums* | *Tenths* | *Real values* |
|---|---|---|---|---|---|
| Mercury | 4 | 0 | 4 | 0.4 | 0.4 |
| Venus | 4 | 3 | 7 | 0.7 | 0.7 |
| Earth | 4 | 6 | 10 | 1.0 | 1.0 |
| Mars | 4 | 12 | 16 | 1.6 | 1.5 |
| Asteroids | 4 | 24 | 28 | 2.8 | 2.8 |
| Jupiter | 4 | 48 | 52 | 5.2 | 5.2 |
| Saturn | 4 | 96 | 100 | 10.0 | 9.5 |
| Uranus | 4 | 192 | 196 | 19.6 | 19.2 |
| Neptune | 4 | 384 | 388 | 38.8 | 30.1 |
| Pluto | 4 | 768 | 772 | 77.2 | 39.4 |

In 1772, when Bode announced this "law," Saturn was the outermost known planet and there was a gap between Mars and Jupiter. In fact, it was this gap that interested Bode. He thought there might be a planet there yet undiscovered. His conjecture was borne out within 30 years by the discovery of a small planet (Ceres) in this general locality, and then another and another, until now some 1,500 asteroids, or minor planets, seem to fill the specifications for this gap in Bode's law. However, no longer could it be held as anything more than a coincidence of numbers, once Neptune was discovered.

The real distances of the planets depend upon finding the earth's distance from the sun, finding the length in miles of an astronomical unit, or determining the solar parallax, to state the same thing in various ways. To accomplish this we must first of all know the size of the earth and accurately locate the observatories that are involved in the work. Obviously, there




**The retrograde motion of the planets—Jupiter's path among the stars for 1942-1945 is shown here—was particularly difficult for ancient watchers of the sky to interpret.**

is no way to measure directly the distance between the earth and sun. Recourse must be had to indirect means, triangulation, that used by the surveyor when he finds the distance across a river, or, more aptly now, the method used to spot the distance of an enemy plane or ship in firing upon it. Even then, the measurement is not made directly upon the sun, but upon another planet or asteroid.

The telescope in the hands of Galileo, crude as it was, revealed many things about the planetary bodies—the crescent of Venus, the moons of Jupiter, the rings of Saturn. As the optical quality of telescopes improved and their magnifying power increased, the markings on Mars, the detailed structure of Saturn's rings, the markings on Jupiter, and more moons came to be known. Then the telescope's ability to make dim objects bright added a new planet, and another, and only 12 years ago still another, and the satellites increased in number until we now count 28. The rotation periods, the sizes, the reflecting power, the atmospheres, the masses, the densities, of planets gradually became known. We learned how they resembled and how they differed from our own world.

The most recently discovered planet, Pluto, is far out on the frontiers of the solar system and was discovered in 1930 by Clyde Tombaugh, of the Lowell Observatory staff. The discovery was the result of a search instituted to find a planet that was still perturbing the motion of Uranus. Nearly a century before, Neptune had been found as a result of calculations depending upon the then unaccounted-for perturbations of Uranus, which in turn had been discovered by chance by Sir William Herschel.

Only a few weeks ago, Mr. Tombaugh asked the writer to correct a misstatement that is current (and I was unwittingly guilty of repeating it on a broadcast) that Lowell's prediction of Planet X, later called Pluto, was based on perturbations of Neptune.

When Herschel saw Uranus for the first time he thought he had discovered a comet. But not Tombaugh, who says:

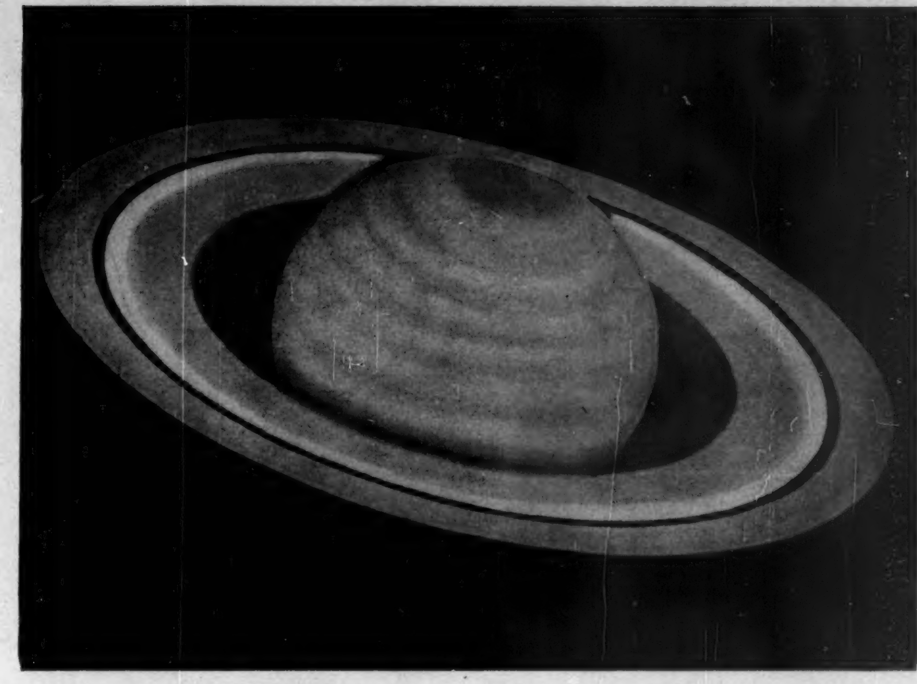
"I did not think Pluto a comet at first. In fact, I thought it a planet beyond Neptune's orbit the instant I saw it, for two reasons: (a) I don't think any comet has ever been actually observed much beyond the orbit of Jupiter. Since the pair of plates being examined were taken at opposition, the shift in position of the object is a direct criterion of its approximate distance, and the shift did indicate it to be about 40 astronomical units distant from the sun; (b) the images were 'hard,' not soft or diffuse, as would be exhibited by a comet. Also, the images looked 'very real.' "

Pluto, from its size, must be classed as a "terrestrial" planet, but there seems to be little terrestrial about it except its size and density. So far from the sun that its temperature is within 100 degrees of absolute zero, Pluto is too cold to possess an ordinary atmosphere. Its poor reflecting power, its small size, and its great distance no doubt delayed its discovery.

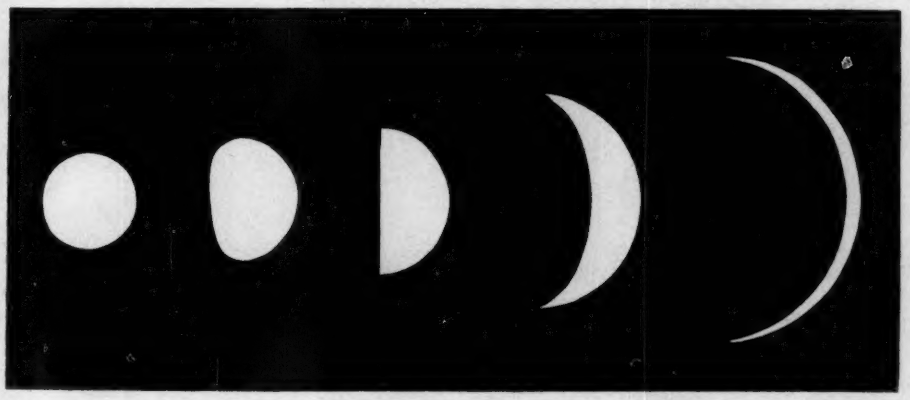
The discovery of Neptune by the calculations of Leverrier and Adams has been recounted many times. Sir William Herschel's finding of Uranus has already been referred to. These two giants—diameters four times the earth's—are so far away that no surface markings are revealed by our telescopes. The spectroscope, though, shows the presence of methane (marsh gas) in their atmospheres in great abundance. This gas absorbs red and yellow light to such an extent that the resulting color of Uranus and Neptune is rather greenish.

Like their neighbors, Saturn and Jupiter, these planets spin rapidly and display considerable polar flattening. Unlike any of the other planets, Uranus has its equator tipped nearly at right angles to its path around the sun, and its four satellites revolve in the same highly tilted plane.

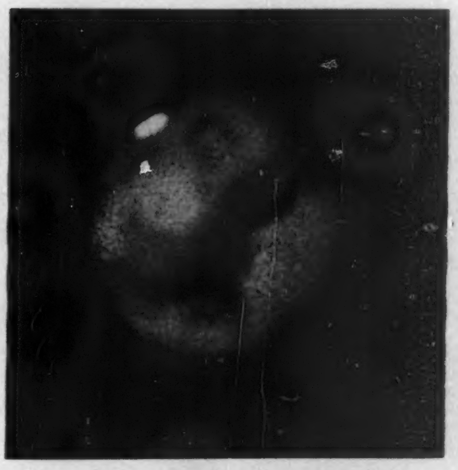
Like the members of any neighborhood, our planetary neighbors show a great variety. They are an interesting lot, these worlds spinning around the sun. Whether the solar system is unique in the universe or typical of similar systems on other stars is still an open question.



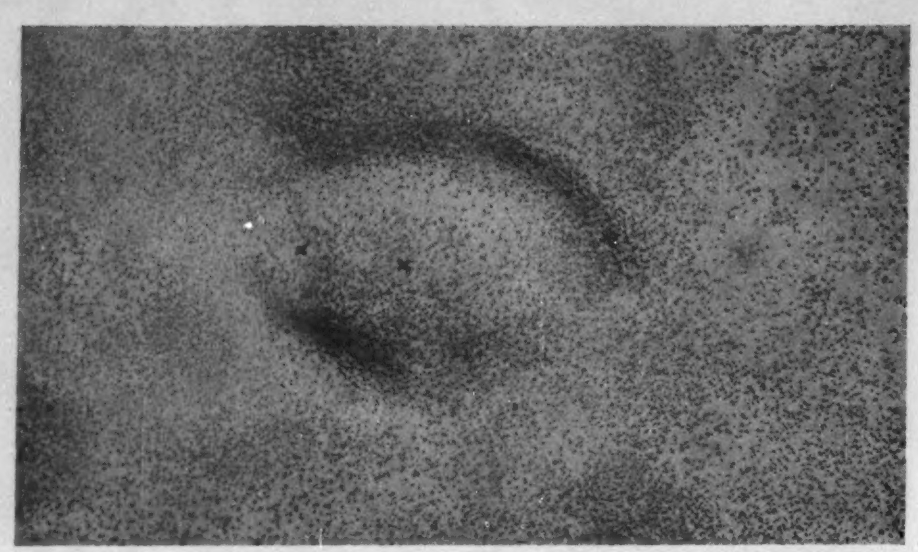
**A drawing by E. E. Barnard, showing Saturn's rings open to their fullest extent.**



**The phases of Venus were predicted by Copernicus, and first observed by Galileo.**



**Mars, with the south polar cap and the Syrtis Major region clearly defined, photographed with the Yerkes refractor.**



Aerial photograph of a problematical meteorite crater near Crestone, Colo., which was discovered by the author in 1941. A magnetometer survey indicates two magnetic masses, whose positions are shown on the photograph. Dimensions of the crater are 350 by 250 feet, a 29-foot depth from the rim crest, and an elevation of the rim above the surrounding terrain of 10 to 22 feet. Exploration of this crater is still in progress. Photo, courtesy of the Air Corps Technical School, Denver, Colo.

# TRENDS IN METEORITICS


By H. H. Nininger

*Colorado Museum of Natural History*

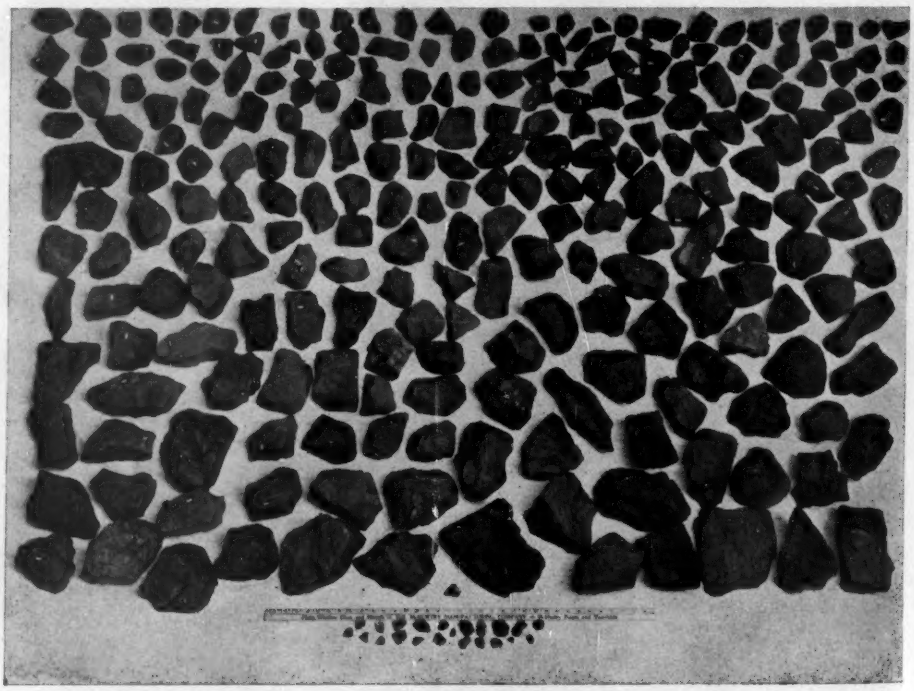

MAN'S first recorded interests in meteorites as such were those of fear and veneration. The sudden, spectacular, and unpredictable arrival of meteorites naturally gave rise to fear. And since they came from the heavens, it was only natural for our unscientific ancestors to attribute meteorites to the gods, and hence to venerate them.

It is probable that even before primitive man ever witnessed the arrival of meteorites, he made use of the metal from the nickel-iron variety, for artifacts have been found in several archaeological excavations and the Eskimos used fishhooks made from the Cape York meteorite, which was one of the clues which led to its discovery by the white man.

In historic times, after the fact of meteorites had been established, interest centered mainly about the questions of their mineralogical character and their origin. From the year 1794, when Chladni set forth the doctrine that certain metallic masses which had been discovered in various parts of Europe must have fallen from space, down to the end of the second decade of the present century, the study of meteorites was almost entirely taken over by mineralogists on the one hand and astronomers on the other. The one notable exception to this was the attempt on the part of D. M. Barringer and his associates to exploit the Canyon Diablo meteorite as a source of valuable metals.

Interest has not waned in the mineralogy and the origin of meteorites, but during the past two decades other aspects equally or more important have been recognized. Astronomers have vastly extended their endeavors to understand these bodies in their relation to the universe and to our own planet. They recognize in meteorites our one tangible connection with the universe beyond our atmosphere. Their relation to comets and to galactic clouds, their relation to asteroids and to dust in space and the atmosphere, to the light of the night sky and to the zodiacal light, their causal connection with lunar topography and their possible bearing on the history and the behavior of the solar system, have all become important. The age of meteorites is now being carefully studied by the measurement of their radioactive contents and comparisons made between them and terrestrial rocks as to the time of origin.

The most important of recent developments in meteorites has come in the field of geology. The recognition of meteorite craters as a topographical and geological feature of the lithosphere opens up vast possibilities for greatly extending our knowledge of meteorites and bids fair to modify materially certain important geological interpretations. Geologists now realize that if the great Arizona crater has been produced by impact, there is no reason why other and even larger impacts may not have occurred and their traces



Some of the 350 fragments of stony meteorite which Dr. Nininger recovered from near Plainview, Tex. The total weight is about 850 pounds.

subsequently been removed by erosion. General acceptance by geologists of the fact of meteorite craters cannot be dated earlier than 1933, yet already seven different locations have been definitely proven, aggregating no less than about two score of craters.

The proven crater locations are Winslow, Ariz.; Odessa, Tex.; Haviland, Kan.; Henbury, Australia; Wabar, Arabia; Kaali Järv, Estonia; Box Hole, Australia. The last-named was reported to me in a private letter from R. Bedford, of the Kyancutta Museum. Mr. Bedford is most familiar with the Henbury craters. He wrote on September 17, 1939, "On my return to Kyancutta I shall be able to send you irons from a recently discovered crater at Box Hole, Central Australia. This is 200 miles from the Henbury crater, with which it has no connection. The iron, though a medium octahedrite, is of quite different type from Henbury." The specimens arrived and are now in the Nininger collection of meteorites.

In addition, several other locations look quite as promising now as did the Arizona crater 20 years ago. Doubtless some and

**For locating meteorites beneath the ground, the author's son carries a magnetic balance.**

perhaps all of these problematical examples shall eventually prove genuine.[1]

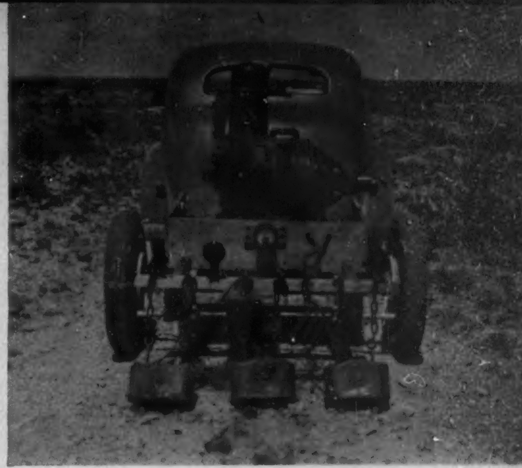
The idea that the peculiar pock-marked lunar topography has been produced by meteoritic impact is constantly gaining in favor, and its final acceptance will prove a powerful stimulus to a more painstaking scrutiny of the earth's surface in search of faint traces of ancient impacts.

The quantitative aspect of meteorites has not yet begun to be taken seriously by the rank and file of either geologists or astronomers. But eventually they will be compelled to move in that direction along a factual path similar to that which my field studies have led me to follow. Twenty years ago I would have definitely rejected the idea that the quantity of meteoritic material arriving on the earth was deserving of serious consideration. Ten years ago I began finding evidence that meteoritic dust clouds and not fallen meteorites were the most important aspect for investigation. A few years later, when I learned that there is a constant rain of meteoritic dust susceptible to measurement, I finally realized that we are on the threshold of a new era in the study of our planet and its relation to the solar system as well as to interstellar space. Meteorites are the corpuscles, so to speak, in the circulatory system of the physical universe.

These corpuscles are the *chondrules* and fragmentary materials of which stony meteorites are composed, together with the meteorites themselves. For once and for all let us put away the erroneous and widespread conception of meteorites as hunks of iron. I admit that most of the collections exhibited in museums give that impression. But all students of meteorites know that this is untrue. Metallic meteorites are the rare exceptions and not the rule. Until the word meteorite ceases to mean *iron,* one can never begin to understand the subject.

Those varieties of stony meteorites containing little or no nickel-iron, such as howardites, eucrites, chladnites, shergottites, whitleyites, and certain carbonaceous forms, are probably 10 times as abundant as are the metallic forms. These extremely stony forms, however, constitute only a minor portion of the whole, so far as our tangible evidence shows. The great bulk of the increment consists of an admixture of stone and metal in which the stony constituents are about 10 to 20 times the metal content.

Stones have great difficulty in getting through the atmosphere to make a landing. Therefore, vast quantities of this stony material are reduced to dust. Clouds, which probably represent many tons of such dust, are left in the wakes of nearly all stony meteorite falls. Dr. Lincoln La Paz has recently calculated that the Pasamonte meteorite of 1933 probably weighed not less than 66,000 *tons,* and possibly much more, when it entered the atmos-



**A magnetic rake devised at the American Meteorite Laboratory has proved that millions of small metallic fragments are buried in the soil surrounding the Arizona Meteor Crater.**

phere. Only about 4,000 *grams* were collected. A huge cloud occupying about 1,000 cubic miles accounted for the principal mass of this meteorite.

Most hypotheses regarding the origin of meteorites give more attention to iron meteorites than to stones. Naturally, this leads to erroneous conclusions. Chondrules, which are the most abundant and therefore the most important of all meteorite constituents, have almost certainly been formed by repeated collisions between crystals and other solid bodies. A situation which would thus provide for the rounding of crystals into chondrules would also produce the fragmentary matrix in which chondrules are generally embedded. Perhaps, when the sun was younger and more active, extruded gases (exceeding the velocity of escape from the sun) crystallized and collected into cometary swarms. Within these swarms chondrules were produced by repeated collisions. The aggregation of the resulting fragments and chondrules gives us our meteorites. Before the comet's career had ended in their dispersion, some of the swarms passed near enough in return trips round the sun to allow for the fusing of some of the con-

**A lake in the center of the main Kaali meteorite crater on the Island of Saaremaa, Estonia. Photo by Clyde Fisher.**

[1] ED. NOTE: For an excellent discussion, by William H. Christie, of our current knowledge of the Siberian meteorite and its probable craters, see *The Griffith Observer,* April, 1942.

Meteoritic dust collected from a roof drainpipe. The spheres are metallic globules rich in iron. The magnification is 100x. Such material sifts down through the atmosphere at the rate of several kilograms per square mile annually.

## Griffith Observatory—Buhl Planetarium

LOS ANGELES residents may find it easy to "enjoy" a blackout by selecting the planetarium chamber of the Griffith Observatory as the place to spend it. This selection will be made doubly easy by the continuous free show which will be given in the planetarium until the all-clear is sounded and by the fact that the observatory building is absolutely fireproof, earthquake-proof, and therefore of protection against almost anything except direct bomb hits.

This is but one of the innovations announced with the new wartime schedule of the Griffith Observatory. In an effort to maintain its educational service to the public, but at the same time to release as many of its staff as possible for wartime work, a study has been made of attendance by the public during the past seven years, from which it is evident that on Fridays and weekends the public convenience is almost completely served.

The Hall of Science will be open Fridays, Saturdays, and Sundays from 2:00 to 10:00 p.m.; the telescope will be available for public observation on these evenings, when clear; planetarium shows will be given on these days at 3:30 and 8:30 p.m. The observatory will not be open at all on the other days of the week. Teachers of school classes and leaders of scouts and similar groups may make advance reservations for Saturday afternoons, the only charge for the admission of children in such groups being the three cents war tax.

Already one member of the staff, Director Dinsmore Alter, has been called to the Army as a colonel in the Coast Artillery. Dr. C. H. Cleminshaw is acting director in Dr. Alter's absence.

In June, the Griffith telescope (admission free) will be directed to Gamma Virginis, Epsilon Lyrae, and the moon, the dates being scheduled in advance, as are those for other objects throughout the summer.

THE only planetarium projector in the world which can be lowered out of sight is in the Buhl Planetarium, Pittsburgh, Pa. On May 3rd, at 3 a.m., the bursting of a water main in an adjoining street flooded the basement of the planetarium building, and endangered the valuable instrument.

The rush of waters flooded the Hall of Light, the Micro Zoo, and the amateur telescope makers' workshops, but quick action by Curator Fitz-Hugh Marshall and two assistants saved the projector. Working in the deepening water, they operated machinery to raise the instrument out of danger.

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stituent grains. In the Lubbock aerolite, recently described by Waldschmidt (*American Mineralogist*, 25, 528-533, 1940), this process was carried almost to the point of completely fusing the mass.

Let astronomers exert half the effort at a precise measurement of the meteoritic infall that they put into the measurement and analysis of light from distant stars, and they will discover that "tangible" astronomy can be as important as light analysis.

Let geologists devote the same painstaking efforts toward the recognition and study of concealed and eroded impact craters as have been bestowed upon paleontology and glaciation, and they will realize that meteoritics can become just as vital as paleontology in the understanding of the earth.

We have a long way to go before the young science of meteoritics can take its place alongside those to which thousands of men have devoted lifetimes of study. But today the way has been opened, and to those who have already devoted years of study, the path looks clear ahead. Sometimes we tend to become impatient when we see millions of dollars spent on the old and much-studied fields of research, while no help is available for our challenging problems; but we shall have to remember that every new field has had to lie fallow for a long time before its possibilities were realized by any but a few.

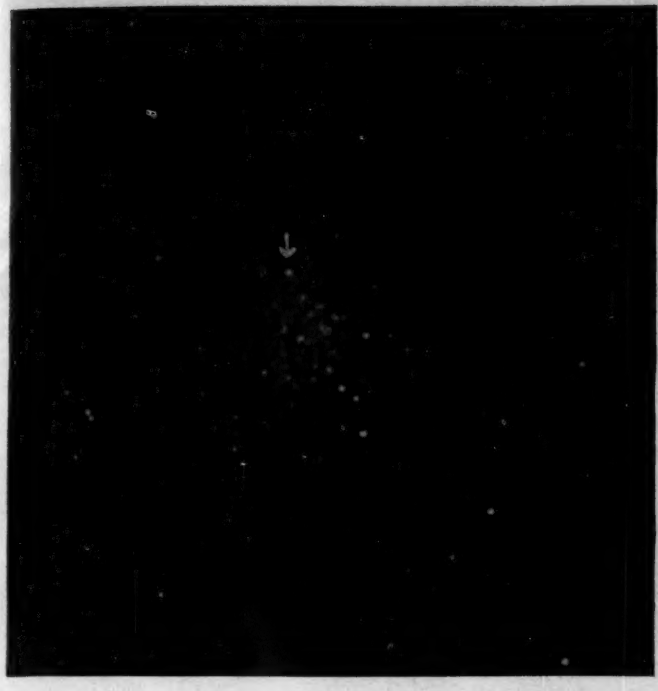
In the opinion of the writer, meteorites will be eventually studied as a phase through which all matter sooner or later passes. They are the products of solar and stellar emanations, the substance of comets, the building material for planet construction, and the debris into which these same planets disintegrate. They are unequally distributed in space and their scarcity or abundance may profoundly influence the history of planets and other bodies.

In 1932, this meteorite fell at Archie, Mo., narrowly missing a farmer who was standing at the edge of his back porch.

Man's brief scientific history and his cosmically short period of observation have given him the impression that meteorites are only very insignificant. The effectiveness of our protective air blanket, the unpredictable arrival of meteorites and their wide distribution, all combine to render difficult any measurement or reliable estimates. Advantage cannot be taken of accumulations, for the reason that the surface of our planet is too active. All surface substances are in a state of flux—so much so that considering the rate of alteration in meteoritic materials, their presence in the soil would scarcely be detectable even though the accretion amounted to as much as an inch each thousand years.

The actual infall probably takes place at a much slower rate at the present time. But we are probably in a mature stage of our solar system's development. The moon, with its battered surface, presents to us a record of a long siege of bombardment. We may assume that the earth has gone through a siege of the same intensity. Probably the record on the moon's face refers to a more intense rain of meteorites in earlier times; but it is possible to account for it even at the rate of celestial bombing to which the earth is now subjected.

The new science of meteoritics must apply the same painstaking methods of study to this interplanetary matter as have been used by geologists in paleontology and by astronomers in their study of the stars. Then and only then shall we be able to appreciate its importance.



**One of the most powerful of astronomical methods is that which employs Cepheid variable stars to find the distances of remote clusters. In this pair of photographs by the David Dunlap Observatory, a Cepheid, near maximum in the first picture, and near minimum in the second, is indicated by arrows. The globular cluster is N.G.C. 6402.**

# SOME ASTRONOMICAL METHODS

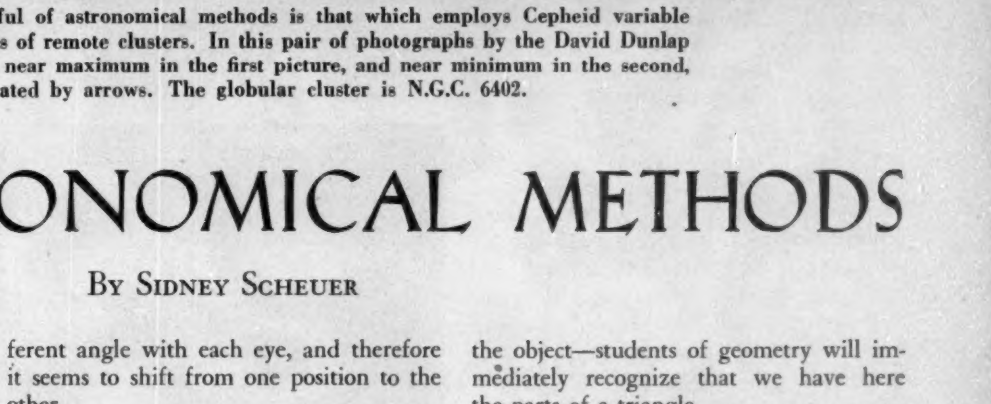
By Sidney Scheuer

"How far away is that star?" "How big is it?" "How do we know?" These are questions everyone asks. Astronomers can answer them, too, and describe the countless methods they have for solving the riddles of far-off suns. Astronomy is a limitless subject, but such amazing progress has been made in the past 50 years that the results are almost incredible. Although the stars, each of which is a sun just like our own, are so distant that they appear even in the largest telescope as mere points of light, just as they look to the unaided eye, it has been found possible to measure the distances to several thousands of them, to determine the actual dimensions of many of them, and even to weigh them. This has been done, not by some mystic sort of necromancy, but by practical methods in everyday use in other types of work as well as in astronomy.

Try a little experiment right now. Hold up one finger before your eyes. Shut one eye and notice the position of the finger with reference to the rest of the room. Now, without moving the finger, close the other eye and open the one which was shut before. The position of the finger seems to have changed, yet you know it hasn't moved, at least not with reference to your eye or the room. You are simply viewing your finger from a different angle with each eye, and therefore it seems to shift from one position to the other.

We have all noticed this effect before, of course. When we ride on a train, objects near us seem to speed past; objects farther away seem to move more slowly; objects at the horizon seem to move very slowly indeed; while if the moon or sun is visible, it doesn't seem to move at all. Movement, in this respect, is simply a difference in the angle at which we view the object—students of geometry will immediately recognize that we have here the parts of a triangle.

Let us call the distance between our eyes the base line. There is an angle at each end of the base line, and it is a law of geometry that if we know one side of a triangle and the angle at each end of it, we can compute all its other parts, that is, we can *solve* the triangle. In other words, if we know the distance between our eyes, and the angles at which the finger is




**The method of surveying to find the distance of terrestrial objects is analogous to the astronomical method of parallax determination. In the first case, the length of the base line O1 and O2, and the angles at O1 and O2 are known; in the astronomical problem, the diameter of the earth's orbit provides a base line, and the angle *A* is twice the *parallax* of the star.**

viewed (measurable from the shift described above), we can calculate the distance of the finger from either of the eyes. For an object farther away, the angles are so inappreciable that we have to have a larger base line, which we can obtain by moving our head or by walking across the room. This is the same principle as is used in surveying.

As we increase the length of the base line, we can measure the distances to objects farther and farther away. With a large enough base line, therefore, we would be able to measure any distance, however great. But, apparently, the largest base line we can use is the diameter of the earth itself—8,000 miles—and in practice it is impossible to use even all of this. Large terrestrial base lines are sufficient, however, to measure the distances to the moon, the nearer planets, and even, with some accuracy, to the sun. But for the stars, which are hundreds of thousands of times farther away, we must use a much larger base line.

How can we get it? Very easily. The earth is 93 million miles from the sun, and travels around it in an almost circular path. So if we pick two opposite points on the earth's orbit, we will get a base line 186 million miles long. If we take photographs of a region of the sky today, and again six months from now (or as nearly six months as the star's declination makes possible, southern stars being difficult for northern observatories because they are below the horizon longer than they are above it), we shall have utilized this base line. Comparison of the photographs will show that any nearby stars in the field appear to have shifted against the farther ones, just as your finger did. By the amount of this shift, we can calculate a star's distance. This is usually expressed as its *trigonometric parallax,* the angle subtended at the star by the radius of the earth's orbit.

Once we know a star's distance, and how bright it appears to us (expressed as *apparent magnitude*), which presumably we can readily observe, we can figure out easily how bright it must really be (expressed as *absolute magnitude*). The equation relating apparent magnitude (m), absolute magnitude (M), and parallax (p) in seconds of arc, is: $M = m + 5 + 5 \log p$.

Surprisingly enough, the nearest stars are not necessarily the brightest ones. Of the nearest 47 individual stars, counting the sun, but 10 are visible to the naked eye. But even with the diameter of the earth's orbit as a base line, most of the stars are so far away that we can measure the distances of comparatively few in this manner. For stars over 100 light-years distant, trigonometric parallax measures become unreliable, so other means must be employed if we are to find the dimensions of the universe.

Fortunately, there are many stars in the sky which vary in brightness from night to night. These are called variable stars. Their light changes may be fast or slow; they may range through several magnitudes or just be discernible in sensitive photometers. But they fall into a number of distinctive groups, such as the long-period variables, the irregulars, and the Cepheids. For the last, a strange fact was found. The period of time required for these Cepheids to go through one entire cycle of variation, from greatest brightness to least brightness and back to greatest, seemed in some way related to their absolute magnitude. It turned out that the longer the cycle, or *period* of a Cepheid, the greater its intrinsic brightness.

Once this simple relationship became established, it immediately was possible to ascertain the distance to any Cepheid variable star, by simply measuring its apparent brightness and determining the period of the cycle. This was to have far-reaching effects, inasmuch as such stars are found almost everywhere in space, and once more, *fortunately,* they are among the intrinsically brightest of stars, and therefore visible at great distances.

If a Cepheid is found among a group of otherwise ordinary stars, it immediately becomes possible to find the approximate distance and dimensions of the entire group. In globular star clusters, for example, those curious formations of thousands of stars packed together in the shape of a ball, variables of the Cepheid type are found. Even though the nearest globular cluster, Omega Centauri, is 20,000 light-years away, its distance has been well established by the Cepheids it contains.

Not only is it possible to find the distance of a cluster, but its size as well. This is the same problem as before, only worked backwards. Here the base line is the diameter of the cluster, but we do not know its linear value. But we do know the two sides of the triangle—the distance to each side of the cluster may be assumed to be the same—and the angle between them, which is the angular size of the cluster as we see it. The rest is simple geometry.

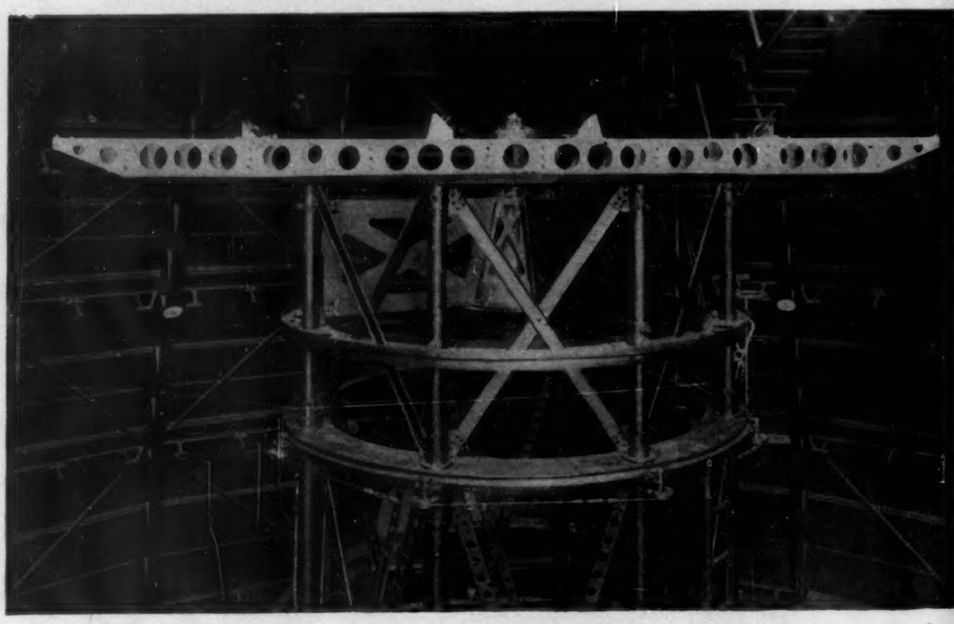
When several globular clusters had been measured, it became apparent that they were all of about the same size. And so still another means of determining distances was placed at the astronomer's disposal. Very distant clusters appear correspondingly small. Incidentally, it is believed that the distribution of the globular clusters in space corresponds to the distribution of the stars in our Milky Way galaxy, at least as far as the center of concentration is concerned. It is therefore important that we know accurately the distances of the globular clusters.

The law of gravitation has been of such importance in astronomy that it is not surprising that it furnishes us with an independent method of finding stellar distances, although, as in the case of the Cepheids, it applies to only one class of stars—double stars or binary systems.

As long ago as the 17th century, Kepler found that a planet moves around the sun in a length of time which is related to its distance from the sun. Sir Isaac Newton, in the theory of gravitation, established the fundamental relationship, and showed that the two bodies' mutual attraction for each other, which depends upon their masses, also entered the problem. Briefly, then, two things affect the length of time it takes a planet to revolve around the sun: the distance and the combined mass of sun and planet.

A great many of the stars which we see with the naked eye prove, upon examination with the telescope, to be attended by

(*Continued on page 23*)



**By means of this 20-foot interferometer, attached to the 100-inch telescope, the apparent diameters of some of the largest stars have been measured.**

# NEWS NOTES

By Dorrit Hoffleit

## WHISTLING METEORS

Strange whistling noises heard when the receivers of their short-wave transmitters were tuned to the carrier wave were investigated by Chamanlal and K. Venkataraman, of the research department of All-India Radio. The whistles appeared as high-pitched notes which either rapidly descended in pitch down to zero frequency, or faded away before reaching the zero frequency. Their duration varied from about a fifth of a second to a few seconds. In the early morning hours they sometimes occurred very frequently, while they were only infrequent in the daytime. The intervals between whistles were irregular. It was found that these noises originated from a reflecting surface moving at the rate of about 64 kilometers a second.

Further observations were carried out which confirmed the investigators' opinion that meteors were responsible. A meteor produces a rapidly moving ionized area capable of reflecting radio waves. The whistling is a manifestation of the Doppler effect. Since the reflecting surface is moving toward the observer, the Doppler effect produces a whistle on the higher frequency side of the transmitter's ground wave.

Velocities computed from this observed Doppler change of pitch are of the same order as velocities determined from visual observations of meteors.

## DESPITE THE WAR

During 1941, the observers at the Boyden Station (Bloemfontein, South Africa) of the Harvard Observatory obtained 7,563 celestial photographs—over 400 more than in the second most fruitful year, 1939. This record was achieved despite the depletion of the staff for military reasons. The plates were taken in connection with some 30 astronomical programs dealing with meteors, comets, spectra, variable stars, clusters, and galaxies. Weather and women helped in making this record possible.

Other South African observatories likewise can look with satisfaction upon their achievements despite the war. For but one example, note the work on proper motions carried out at the Cape Observatory (see "News Notes," *Sky and Telescope*, March, 1942).

## SUPERNOVA OF 1054

In the year 1054, the Chinese observed a previously unknown object in Taurus which they called a "guest star." Since 1921, various investigations have tended to prove that the Crab nebula, which is remarkably close to the recorded position of this guest star, is actually its expanding-shell remains. Later, when the distinction between ordinary novae and supernovae was recognized, it seemed most likely that the star had been a supernova. The evidence was, however, not altogether infallible.

Two papers in the April issue of the *Publications* of the Astronomical Society of the Pacific now add more decisive evidence than has hitherto been available for the supernova characteristics of this star. J. J. L. Duyvendak, at Leiden, has translated Chinese records from which the brightness at maximum, the duration of naked-eye visibility, and something on the shape of the light curve may be inferred. These are the data necessary for the determination of the true luminosity of the supernova at the time when it attained its greatest brilliance. N. U. Mayall (Lick) and J. H. Oort (Leiden) have collaborated in utilizing Duyvendak's translations. It appears that the guest star of 1054 was not only a supernova; it vies with the one discovered in 1938 in the galaxy N.G.C. 4182 in being the most luminous yet discovered. At its brightest it exceeded the luminosity of the sun by 100 million times.

## COMET NEWS VIA COMPLEX ROUTE

The latest rediscovery of the 5-year periodic Comet Grigg-Skjellerup was made on May 9th by Japanese astronomer Kanda. His observation and the route by which we received the news provide evidence that astronomy still transcends international barriers. Our information came by cable from Lund, Sweden, which has replaced Copenhagen, Denmark, as the clearinghouse for European and Asiatic astronomical information. But in this case, Lund did get the message from Stroemgren at Copenhagen, who presumably had received it directly from Japan.

In the *Handbook* of the British Astronomical Association for 1942 appears an ephemeris for the comet, computed by English astronomer F. C. Cripps. The expected positions from January 1st to August 13th are given, so it was no surprise when Dr. G. van Biesbroeck, Belgian-American astronomer at Yerkes Observatory, observed the comet about the middle of April as a 15th-magnitude object near Betelgeuse in Orion. It was almost exactly at the position predicted by the ephemeris.

At the time of the Japanese rediscovery, neither Europe nor Asia knew of Dr. van Biesbroeck's observation, inasmuch as radio and cable messages can no longer be sent to Sweden, and apparently the Harvard Announcement Cards are still in transit.

This complex international phase concerning an event in the history of Comet Grigg-Skjellerup is not unusual for it. Originally it was discovered by Grigg, in New Zealand, in 1902. Then, in 1922, the Finnish astronomer, Skjellerup, rediscovered it. Sweden, Denmark, England, Belgium, the United States, and now Japan, make eight countries which have participated in study of this cosmopolitan comet.

The Japanese observation on May 9th gives the magnitude as 10, considerably brighter than expected on the basis of the April report. Perihelion passage occurred on May 23rd, at about 0.85 astronomical units from the sun, and 0.49 astronomical units from the earth. Nearest approach to the earth is expected about June 24th, at about 0.33 astronomical units, or 31 million miles. Since the distance from the sun will then be one astronomical unit, greatest brilliance, of about the 9th magnitude, will probably have been reached a short time before June 24th, but this is subject to the comet's intrinsic variations in light.

The ephemeris, which the comet is following very closely, is as follows:

| | | h | m | ° | ′ |
|---|---|---|---|---|---|
| May | 25 | 8 | 11.3 | +19 | 32 |
| June | 2 | 8 | 52.3 | 25 | 15 |
| | 10 | 9 | 48.6 | 31 | 54 |
| | 18 | 11 | 2.5 | 38 | 12 |
| | 26 | 12 | 33.3 | 41 | 39 |
| July | 4 | 14 | 3.7 | 40 | 36 |
| | 12 | 15 | 15.7 | 36 | 15 |
| | 20 | 16 | 7.9 | 30 | 43 |
| | 28 | 16 | 45.6 | 25 | 16 |

## BRUCE MEDAL FOR 1941

Dr. J. H. Oort, assistant director of the Leiden Observatory, has been chosen the Bruce Medalist for 1941. The gold medal, a gift of Catherine Wolfe Bruce in 1897, is awarded not oftener than once a year "for distinguished services to astronomy," by the Astronomical Society of the Pacific.

## A.A.S. MEETING

The 68th meeting of the American Astronomical Society will be held at Yale University from June 12th to 14th, inclusive. The tentative program appeared in *Sky and Telescope* last month.

## . . . AND THE WAR

The Council of the Royal Society of Arts (British) encourages efforts toward the improvement of navigation in offering a prize of £50 under the Thomas Gray Memorial Trust, the objects of which are the "advancement of the science of navigation and the scientific and educational interests of the British mercantile marine."

In 1940 the Council offered a similar prize which was awarded to H. C. Walker, of Surrey, for his "Portable Valve Lifeboat Equipment," a self-contained radio auto-transmitter, designed for the purpose of saving life at sea.

On December 20, 1941, the Carter Observatory at Wellington, New Zealand, was officially opened by the Rt. Hon. the Prime Minister, P. Fraser. The director of the observatory, M. Geddes, joined the Royal New Zealand Navy on December 13th. The acting director, J. L. Thomsen, hopes to carry on as much of the planned program of the observatory as possible. Work on sunspots and observations of the aurora australis are reported in recent publications from the Carter Observatory.

A view from the air of the Huancayo (Peru) Magnetic Observatory of the Carnegie Institution of Washington. It is uniquely situated on the geomagnetic equator at 11,000 feet above sea level in the Peruvian Andes, about 125 miles east of Lima.

# The Variations of Geomagnetism

By H. D. Harradon

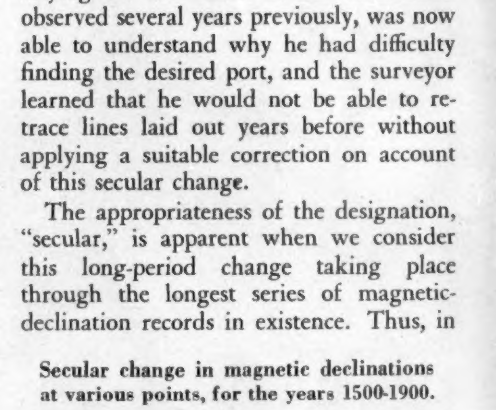
*Department of Terrestrial Magnetism, Carnegie Institution of Washington*

THE magnetic field which pervades the earth and extends with diminishing intensity far out into surrounding space is subject to many types of variation. Some of these changes are of a progressive nature, continuing for long periods of time in one direction; others exhibit a definite periodicity, which is chiefly attributable to the position of the earth with respect to the sun and moon; and still others manifest little periodicity, and occur as violent agitations of the magnetic elements[1] simultaneously over the whole earth. Because of the capricious and transient character of the last, they are known as magnetic storms. It is thus obvious that the earth's magnetism is never quiet, even in its periods of relative calm. All the changes are embodied in the records obtained by the variation instruments at the various magnetic observatories distributed over the earth, which operate in order that accurate information may be available for practical requirements as well as for theoretical investigations of the phenomena of geomagnetism.

If we compare the successive annual means of the magnetic elements obtained at an observatory over a number of years, we observe a gradual change from year to year which in the course of time reaches considerable proportions. Because of the extremely long period required for its development, this phenomenon is known as the *secular variation* (from the Latin word, *saeculum,* signifying a long period of time). Its discovery occurred in 1634 when Henry Gellibrand, a professor of mathematics at Gresham College, determined the magnetic declination at Diepford, near London, obtaining the value 4° 6′ east. Comparing this value with that measured by one of his colleagues on June 13, 1622, namely 5° 56½′ east, and one obtained in 1580 by Borough and Norman, 11° 15′ east, he found that an obvious and considerable change in declination had taken place in a half century. Up to that time, it was generally believed that the value of the declination, though varying from place to place, remained stationary at any one point. The tremendous importance of this discovery became at once evident. The mariner, who sailed for some distant place relying on the value of the declination observed several years previously, was now able to understand why he had difficulty finding the desired port, and the surveyor learned that he would not be able to retrace lines laid out years before without applying a suitable correction on account of this secular change.

The appropriateness of the designation, "secular," is apparent when we consider this long-period change taking place through the longest series of magnetic-declination records in existence. Thus, in

**Secular change in magnetic declinations at various points, for the years 1500-1900.**



[1] The three quantities, declination ($D$), inclination or dip ($I$), and horizontal intensity ($H$), are usually referred to as the magnetic elements. The magnetic declination is the angle between the astronomical meridian and the magnetic meridian (vertical plane through any point defined by the direction of lines of force at that point); the inclination is the angle between direction of the lines of force and the horizontal plane; and the horizontal intensity is the force holding the compass needle in the plane of the magnetic meridian.

London, the needle in 1580 pointed 11° east of north, then gradually changed its direction and progressed westward until in 1818 it reached its maximum of 24° west of north, and then began shifting its course toward the east; now it points about 11° west of north. This motion of the needle has led to the suggestion that about 480 years would be required for the needle at London to perform a complete oscillation, but more recent observations do not tend to support the idea that this cycle is necessarily a closed one. Other periods have been suggested for other places, but further observations will be required to verify or disprove such assumptions. A secular variation is discernible in all the other magnetic elements. For example, the value of the dip, or inclination, in London in 1576, was recorded as 71° 50′. In 1700 it was found to be 74° 31′, and at the present time it is about 67°. Records of the total force go back only a little over 100 years.

Nearly all countries maintain magnetic surveys in order that within their borders the distribution of the magnetic elements, especially the declination, may be known. The detailed results obtained from the various observation stations are usually prepared in the form of tables. Most convenient, however, is the graphical representation on a map. On such maps, lines are drawn through points of equal declination, inclination, or horizontal intensity, as the case may be, and the maps are called *isogonic, isoclinic,* or *isodynamic,* respectively. The lines do not actually exist in nature, but depict artificially the distribution of the elements in a very practical way. For the United States, the magnetic survey forms part of the work of the Coast and Geodetic Survey, which revises its isomagnetic charts at intervals as new data on the secular change are collected. Isomagnetic charts for the whole earth are issued by the United States Hydrographic Office and other leading hydrographic bureaus of the world. It is to be noted that the isogonic lines do not always run in a regular manner, but in places are distorted by areas of local anomaly which may be due to masses of magnetic material in the earth's crust.

Since no actual observations are available earlier than the 16th century, attempts have been made by other means to extend our knowledge of the earth's magnetism to earlier dates. To this end, European investigators have studied the magnetization of eruptive rocks, baked clays, and ancient potteries, and a pretentious examination of magnetic data obtained from successive lava flows of Mt. Etna was made in recent years. This study rested on the assumption that the lava retained the direction of the earth's magnetic field at the time of its solidification by cooling, and that samples taken from flows of known dates would yield information regarding the secular change in the region in question. The results of these investigations have in this respect proved rather indefinite.

A study of the varved (layers of) Pleistocene clays from an old glacial lake near New Haven, Conn., formed at the recession of the last glaciation, seems more promising. This was made recently at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. These glacial varves have marked advantages over volcanic rocks. Their relative chronology has been established in much the same way as that of tree rings. They have been subjected to very little chemical or physical change, and their pristine magnetization has been preserved under uniquely fortunate conditions. Moreover, a suitable electromagnetic method was developed for determining the direction of magnetization of these feebly polarized sediments. Measurements performed on a series of varves, representing some 200 consecutive years, indicated that the average direction of magnetization was nearly 30 degrees west of the present direction in that region. The successive varves exhibit a gradual variation in direction, suggesting that the secular change when they were formed was progressing at about the same rate as it is today.

Similar measurements performed on an 8-foot core of sediment taken from the floor of the Atlantic Ocean, and estimated to represent several thousand years of deposition, suggest a possible gradual variation in direction of magnetization amounting to over 60 degrees. This is a greater range in secular variation than has ever been recorded.

Theories have not been lacking to account for the secular change, but no acceptable explanation of this mystery has yet been advanced. It seems to be connected with changes which are in progress in the earth's interior regarding which we have more speculation than facts.

In contrast to the slow and progressive secular variation, there are a number of transient variations which run their course in comparatively brief periods. Chief among these are the solar and lunar *diurnal* and the *annual variations*. Moreover, the period of slightly over 11 years connected with sunspot activity recurs with marked regularity in geomagnetic phenomena. All these changes are more susceptible to investigation than the secular change, not only because of the shortness of their periods, but also because their origin is to be sought chiefly in the upper regions of the earth's atmosphere, regarding which it is possible to obtain some information. Particularly is the diurnal, or daily, variation of much interest, since it reflects in various ways the solar influences, and because the investigation of its cause led to the concept of a conducting layer in the high atmosphere.

An analysis of the diurnal variation at different observatories has shown that its course exhibits considerable similarity for observatories in about the same latitude. Its period is the solar day, and its amplitude is greater in the summer than in the winter months in the northern and southern hemispheres, respectively, and the amplitude also is greater during years of sunspot maximum than those of sunspot minimum. The results obtained at various points distributed over the earth's surface have permitted the approximate analytical representation of a diurnal variation field *progressing with the earth's rotation* and

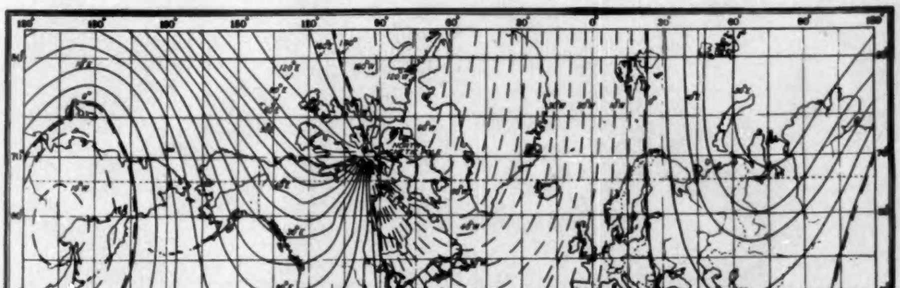


**Chart showing the lines of equal magnetic declination. This chart is based largely on observations made on the cruises of the non-magnetic ship, *Carnegie*. Note the north and south magnetic poles.**

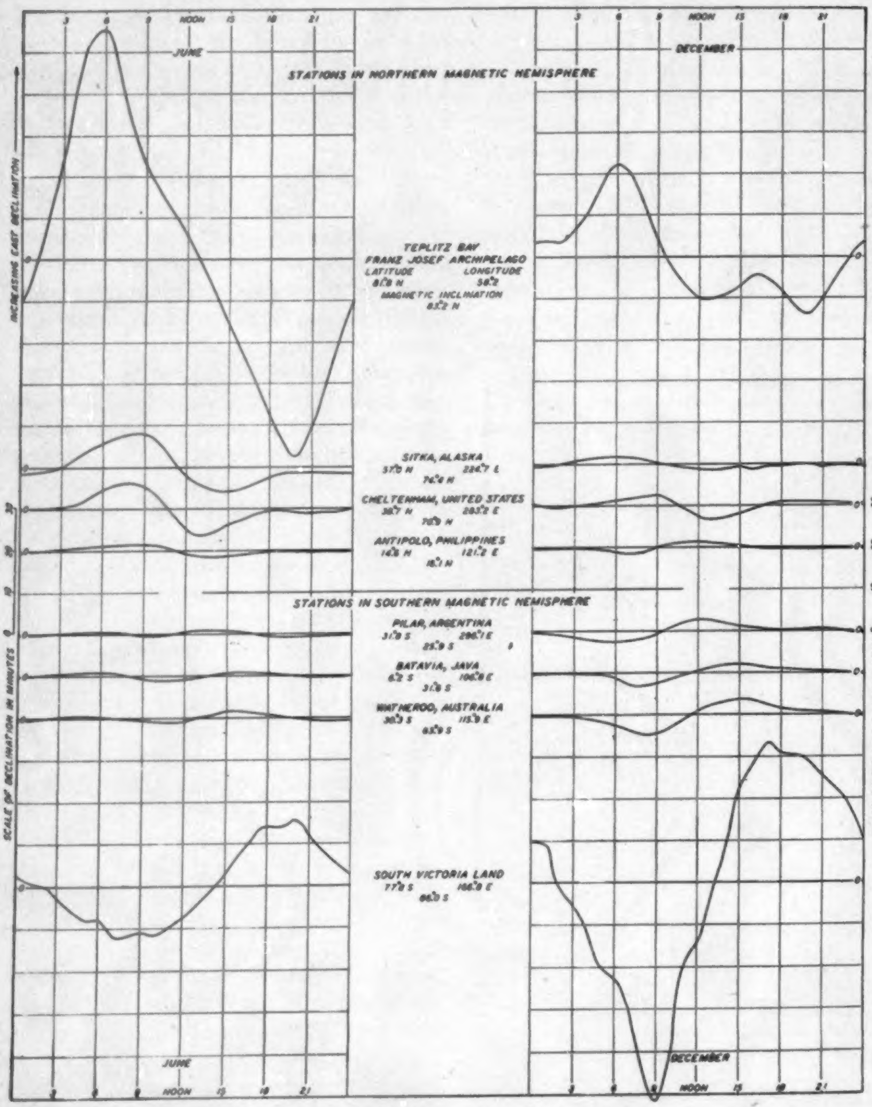
the evaluation of its component parts, having their respective origins inside and outside the earth.

The first investigations in this direction were carried out by Schuster in 1889, on the basis of the results from four observatories only. The effects having their origin outside the earth, as verified later by a more careful study by Chapman, were found to constitute three fourths of the whole. The portion originating in the earth was thought to be chargeable to the action of currents produced by induction in the earth from the external currents responsible for the principal portion of the diurnal variation.

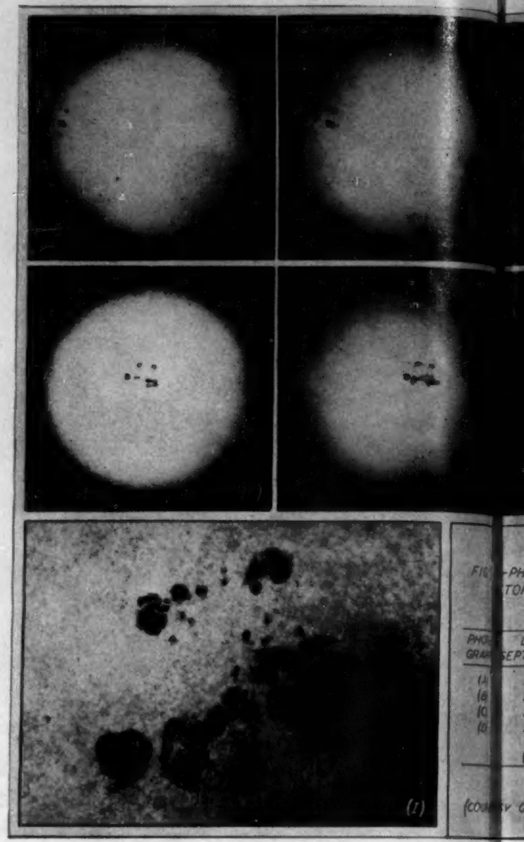
The character of this variation may be derived from the changes in declination on a magnetically quiet day at an average station north of the geomagnetic equator. The north end of the compass needle begins before sunrise to move toward the east, continuing until about 8 or 9 o'clock local time, when it reverses its direction and moves toward the west until about 1 p.m. It then resumes its eastward motion until around 5 p.m., after which time it remains fairly stationary, except for minor fluctuations, until morning. There are irregularities, due to local circumstances, however, which affect the diurnal variation despite this general similarity in the same latitude. At a station south of the geomagnetic equator, the motion with reference to the north end of the needle is opposite to that above described.

An idea of the importance of the diurnal variation, which affects all the magnetic elements, may be had from an inspection of range as derived from 10 selected quiet days, according to the records of the Cheltenham Magnetic Observatory of the United States Coast and Geodetic Survey, situated about 15 miles southeast of Washington, D. C., for the months of January and August, 1923 (year of minimum sunspot activity), and 1928 (year of maximum activity):[2]

| | | *Jan.* | *Aug.* |
|---|---|---|---|
| Declination | 1923 | 6'.8 | 10'.6 |
| | 1928 | 10'.9 | 14'.7 |
| Inclination | 1923 | 1'.8 | 2'.1 |
| | 1928 | 2'.7 | 2'.8 |
| Horizontal | 1923 | 35γ | 44γ |
| intensity | 1928 | 52γ | 52γ |




**Diurnal variation or inequality in magnetic declination. Curves show seasonal changes and modification in ranges for different latitudes.**



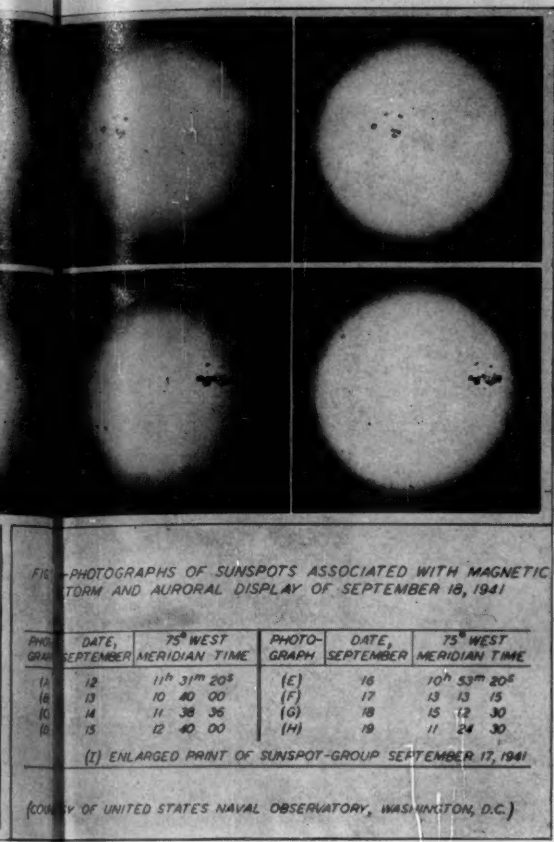
**Sunspots associated with the magnetic ... 1941, as photographed by the United S... N**

There is also a small periodic variation in the earth's magnetic field depending on the position of the moon with respect to the earth. It is less than 1/10 as large as the solar diurnal variation, and because the solar and lunar days are of nearly equal length, can only be derived by laborious analysis of long series of observations. It is too small for any practical purpose, its chief interest being in connection with ionospheric investigations.

If the secular change is eliminated from the monthly mean values of the magnetic elements, there remains a systematic change of cyclic nature known as the annual variation. Its amplitude is very small, hardly exceeding a minute of arc in declination at North American stations. It has not been extensively investigated. Its origin is probably to be sought outside the earth.

A third category of magnetic variations consists of magnetic storms or perturbations. These disturbances occur almost simultaneously over the whole earth. They have nothing in common with weather, which is more local in character. Unlike thunderstorms or windstorms, often destructive in their violence, these magnetic storms, even the most intense, may occur

[2] Expressed in minutes of arc for declination and inclination, and in gammas (γ), the unit used for strength of field (1 γ = 0.00001 centimeter-gram-second unit).



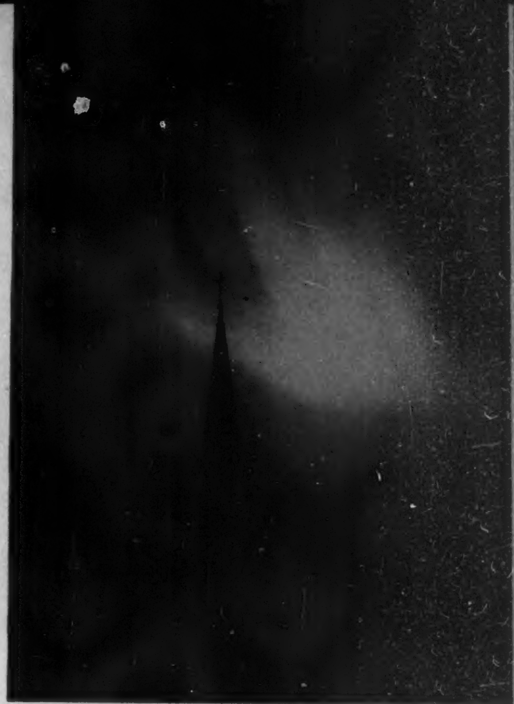

gnetic m and auroral display of September 18,
ited S Naval Observatory, Washington, D. C.

in the fairest weather, their presence being betrayed only by the agitations of the magnetic needle or the disruption of the regular traces of magnetic registration. In general, they occur from two to five times each year, lasting about two days, and at times affecting cable and radio transmission more or less severely, as, for example, during the remarkable aurora of September 18, 1941, widely observed in the United States. They are accompanied by auroral displays and are usually observed when large spots are visible near the center of the sun's disk. Attempts to predict their occurrence on this basis, however, have not been attended with much success, since often no storm takes place even when spots are observed, and conversely, often no spots are visible when a magnetic storm is in progress.

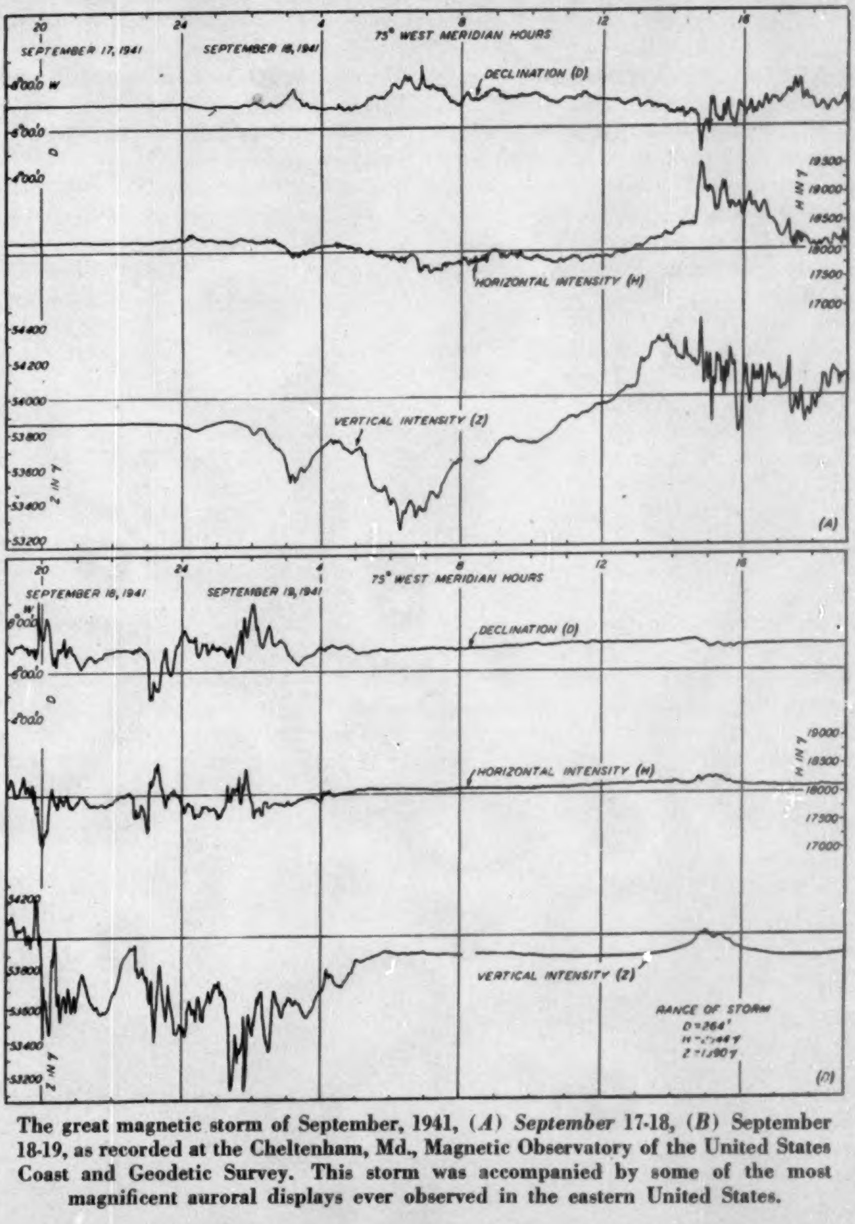
In the correlation of magnetic disturbance with other physical phenomena, some measure of magnetic activity is required. By international agreement such a measure was established in 1906 at some 50 magnetic observatories. Numbers were assigned for each day on the scale 0 to 2, according to whether the magnetic elements were quiet (0), moderately quiet or disturbed (1), or greatly disturbed (2). On the basis of these, the Meteorological Institute of the Netherlands, at De Bilt, Holland, compiled lists of international magnetic character-numbers to express the magnetic activity of each day. In recent years, these figures have been extended backward to the year 1884 on the basis of available registrations at observatories.

For certain purposes this time-honored system of magnetic classification was found inadequate, and in 1939 an improved scheme known as the three-hour-range index was introduced. For the formation of this measure, each collaborating observatory assigns to each three-hour interval beginning at 0h, 3h, . . . G.M.T., one of the digits, 0 to 9 (0 indicating a quiet and 9 an extremely disturbed period). This more elaborate system was designed to meet the requests of the International Union of Scientific Radiotelegraphy and other bodies for more detailed information regarding magnetic activity than that afforded by the daily magnetic character-figures. The new measure has already proved its value in problems concerning radio reception over large distances.

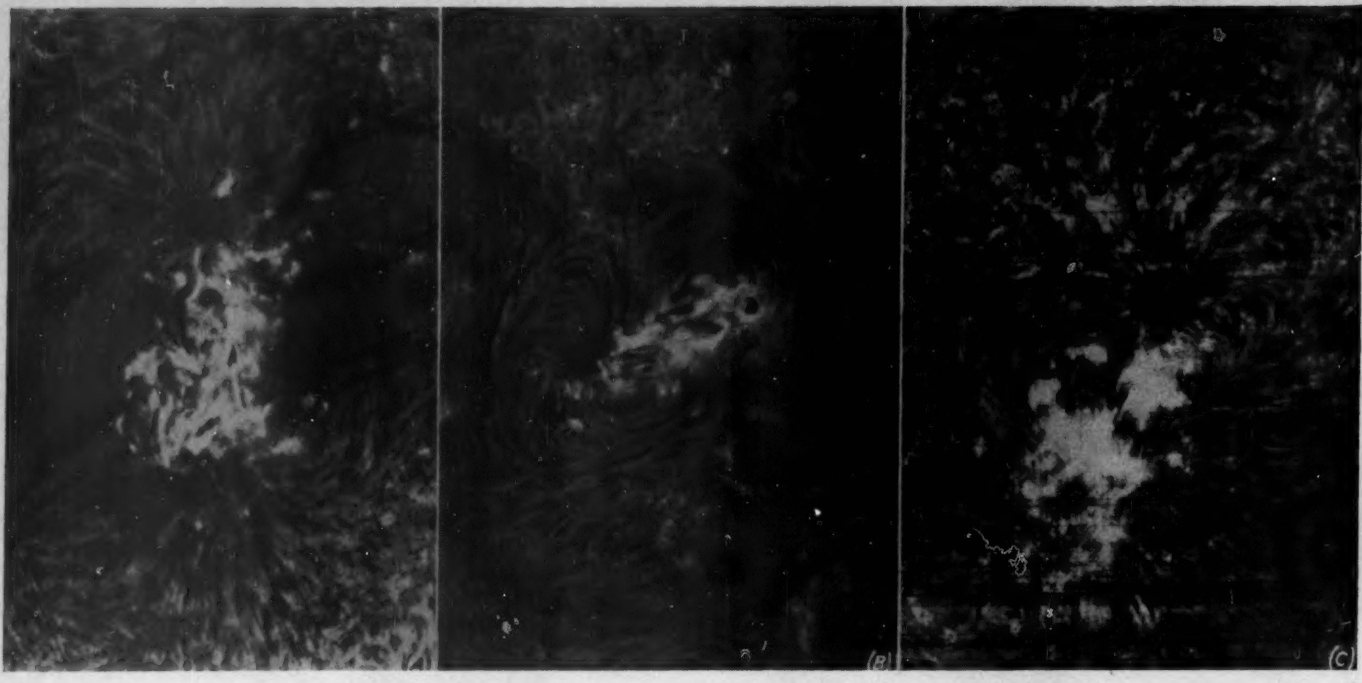
Many attempts have been made to formulate a satisfactory theory to explain magnetic storms. About 1896, Birkeland proposed that electrons approaching the earth would be turned aside by the earth's



**The September 18, 1941, aurora, photographed at Cambridge, Mass., by R. Newton Mayall.**




**The great magnetic storm of September, 1941, (*A*) *September* 17-18, (*B*) September 18-19, as recorded at the Cheltenham, Md., Magnetic Observatory of the United States Coast and Geodetic Survey. This storm was accompanied by some of the most magnificent auroral displays ever observed in the eastern United States.**




**Various types of hydrogen flocculi. (*A*) The flocculi over bipolar groups often resemble iron filings over a bar magnet similar to the lines of force of the earth's magnetic field; (*B*) the flocculi over single spots sometimes have a spiral form; (*C*) the flocculi over single spots are generally complex, their filaments being radial or curved in either direction.**

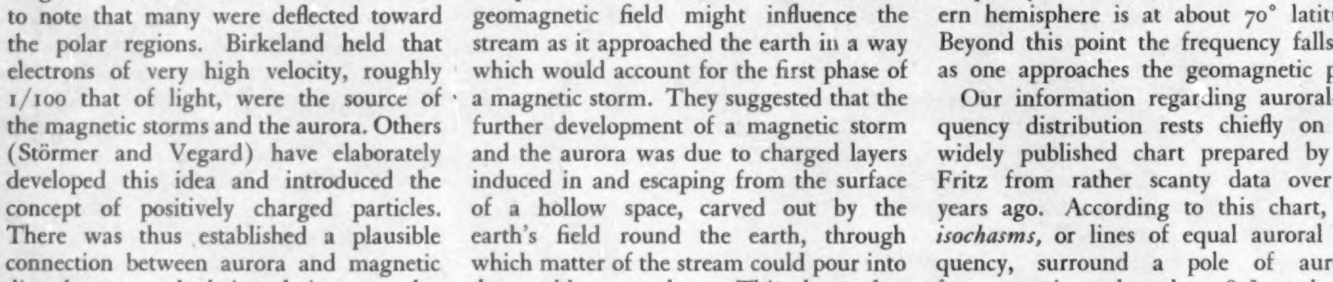
magnetic field. By exposing a magnetized sphere to cathode rays in a vacuum chamber, he was able to observe the effect of the magnetic field on their distribution and to note that many were deflected toward the polar regions. Birkeland held that electrons of very high velocity, roughly 1/100 that of light, were the source of the magnetic storms and the aurora. Others (Störmer and Vegard) have elaborately developed this idea and introduced the concept of positively charged particles. There was thus established a plausible connection between aurora and magnetic disturbances and their relation to solar activity. Birkeland's experiments were resumed and extended by Brüche about 1930, and verified by Störmer's extensive mathematical calculations.

In 1923, Chapman investigated the motion and effects of a neutral ionized stream of solar corpuscles under the influence of the geomagnetic field. These streams are emitted from a small area on the rotating sun in a geometrical pattern resembling the spray from a garden hose, overtaking the earth on its afternoon side as it proceeds along its orbit. He concluded that the stream would be only slightly deflected and would not explain the polar aurora. A later investigation by Chapman and Ferraro indicated that the geomagnetic field might influence the stream as it approached the earth in a way which would account for the first phase of a magnetic storm. They suggested that the further development of a magnetic storm and the aurora was due to charged layers induced in and escaping from the surface of a hollow space, carved out by the earth's field round the earth, through which matter of the stream could pour into the earth's atmosphere. This theory has not yet been fully developed.

Although the systematic study of the aurora may be said to have been begun over 200 years ago by De Mairan, and as early as 1716, Halley had pointed out that auroras are accompanied by magnetic disturbances, no very simple relation applicable to individual cases has yet been found, despite the many investigations that have been made of the correlations. Of especial importance in this connection is the geographical distribution of auroras and their position in space. In equatorial regions auroras are almost never seen. Their frequency increases with increasing latitude until a zone of maximum auroral frequency is reached, which in the northern hemisphere is at about 70° latitude. Beyond this point the frequency falls off as one approaches the geomagnetic pole.

Our information regarding auroral-frequency distribution rests chiefly on the widely published chart prepared by H. Fritz from rather scanty data over 50 years ago. According to this chart, the *isochasms,* or lines of equal auroral frequency, surround a pole of auroral frequency situated at about 80° north latitude and 75° west longitude. Recent investigations have shown that the auroral pole, which the lines of equal auroral frequency encircle, coincides with the magnetic axis point, that is, the point where the magnetic axis[8] intersects the surface of the globe. A similar situation is believed

[8] This is the central axis of magnetization for the uniformly magnetized sphere yielding the closest simple approximation to the earth's magnetism; it intersects the earth's surface in northern Greenland.

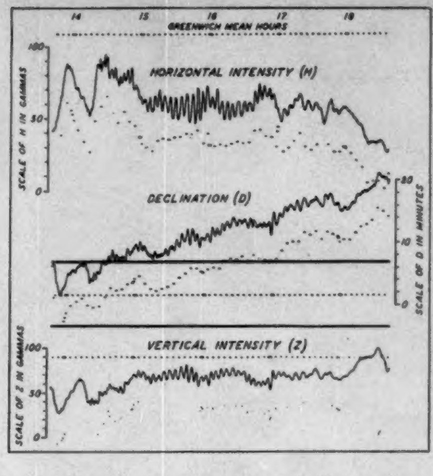



**Geomagnetic activity (*u*) and relative sunspot-numbers (*R*), annual means, 1835-1941. The points marked by the small circles are the yearly means from January to December.**

to exist in the southern hemisphere, but the lack of observational data in those regions permits us to make only an approximate delineation.

The suggestion put forth by Balfour Stewart over 50 years ago, and later verified by Schuster by mathematical analysis, that the seat of magnetic perturbations is to be sought in the upper regions of the atmosphere, led to the discovery of the ionosphere (ionized regions in the high atmosphere). This is one of the important results of the theoretical study of magnetic observations. The presence of these ionized regions in the ionosphere was predicted on the basis of geomagnetic fluctuations before their use in radio propagation was discovered. Because of the abundance of electrified particles contained therein, the ionosphere is the most probable location of the electric currents which produce the magnetic variations on the earth. This region is subject to influences emanating from the sun: light of short wave length and high ionizing power, solar charged and uncharged particles. These effects originate in certain active areas of the sun and vary in intensity with the waxing and waning of these areas and the change of their position with respect to the earth.

The fact that magnetic disturbances depend on emissions from active regions on the sun's surface has given rise to investigations of possible periodicities in their occurrence. When, for example, an active region persists through several solar rotations, the magnetic variations connected




**Giant pulsations as recorded at the Hermanus (Cape Colony) Observatory in South Africa, March 1, 1942.**

with it should likewise reappear at intervals corresponding approximately with the period of rotation. In fact, it has been found that magnetic disturbances often tend to recur at intervals of about 27 days, which is the mean synodic rotation period of the sun. The 27-day recurrence tendency, however, is often not so marked for intense magnetic storms as for weaker perturbations. This is explained on the basis that the most violent storms are associated with eruptive phenomena of great intensity but short duration—much less than the time of a solar rotation. Less intense perturbations are probably associated with less intense but more lasting solar phenomena, since they sometimes persist through several rotation periods. The irregularities in concentration in the emitted beams or streams of particles also explain the succession of transient changes in the earth's field varying in magnitude with the size of individual clouds of particles in the stream.

An interesting type of magnetic disturbance is the so-called *pulsation,* a small fluctuation lasting from one half to three minutes and occurring most frequently around midnight. Their magnetic effect at the earth's surface seems to resemble that which would be produced by a short oscillating magnet in the atmosphere. They have been recorded simultaneously at stations widely distributed over the earth, but unusually large ones (giant pulsations) are especially observed near the auroral zone, but according to the records obtained during the Polar Year 1932-33, they are rarely recorded within it.

It is now clear that the magnetic needle, as a result of all these changes, even in its calmest moments is never still. The earth's magnetic field, by the action and superposition of these many forces, presents an aspect like the open ocean in all its varying moods, through whose placid calms and raging tempests its directive force, acting on the delicate needle, guides the mariner along his plotted course. In the multiplicity of its movements, the earth's magnetism, in common with other forces at work in nature, illustrates the adage that "nothing constant is but change."

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# DO YOU KNOW?

## By L. J. Lafleur

*I. Score four points for each question correctly answered, and one point for each question where you do not attempt to select the answer.*

1. A gaseous mass which loses energy contracts and becomes hotter. This is known as ..........'s law.
   a. Huygens c. Lane
   b. Herschel d. Lorentz

2. A gaseous or liquid body revolving around a primary of the same density will break up if within 2.44 radii of the central body. This is known as ..........'s limit.
   a. Fizeau c. Doppler
   b. Zeeman d. Roche

3. A magnetic field may divide a spectroscopic line into two or three parts. This is known as the .......... effect.
   a. Fizeau c. Doppler
   b. Zeeman d. Roche

4. Radial velocity of a source of light towards the observer causes a shift of spectral lines towards the violet. This is the .......... effect.
   a. Fizeau c. Doppler
   b. Zeeman d. Roche

5. That the radius vector of the orbit of a revolving body sweeps out equal areas in equal times is one of ..........'s laws.
   a. de Sitter c. Bohr
   b. Newton d. Kepler

6. There is a limit to the accuracy possible in measuring space and time simultaneously, according to the principle of uncertainty of
   a. Kepler c. Bode
   b. Heisenberg d. Einstein

7. That there is a least unit of energy is implied in the quantum theory of
   a. Poincare c. Planck
   b. Einstein d. Stark

8. That the force of gravitation between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between them is the law of
   a. de Sitter c. Bohr
   b. Newton d. Kepler

9. The dimensions of space are determined by the amount of matter, according to a hypothesis by
   a. Russell c. Einstein
   b. Jeans d. Maxwell

10. That binary systems are produced by the fission of a rotating liquid star is a hypothesis by
   a. Russell c. Einstein
   b. Jeans d. Maxwell

*II. In each of the sets of four terms given below, three terms belong together more naturally than does the fourth belong with them. Select the fourth term in each case. Score four points for each correct answer, and one point for each question where you do not attempt to select the answer.*

1. Uranus, Mercury, Ceres, Pluto.
2. Ganymede, Callisto, Io, Pyrrho.
3. Grus, Huygens, Pictor, Gemini.
4. Algol, Mira, Pollux, Lyra.
5. Adams, Balliol, Chamberlin, Galileo.
6. Mt. Wilson, Lick, Lowell, Campbell.
7. Gregorian, Cassegrainian, Newtonian, Copernican.
8. manometer, interferometer, polariscope, spectroscope.
9. astronomical unit, angstrom, parsec, gamma.
10. light-year, sidereal year, tropical year, anomalistic year.
11. Augustus, Ptolemy, Plato, Aristotle.
12. Biela, Roy, Encke, Tempel.
13. Russell, Kepler, Shapley, Jeans.
14. 67,000,000; 93,000,000; 141,000,000; 266,000,000.
15. aberration, Doppler effect, polarization, Roche's limit.

(*Answers on page 21*)

# BEGINNER'S PAGE

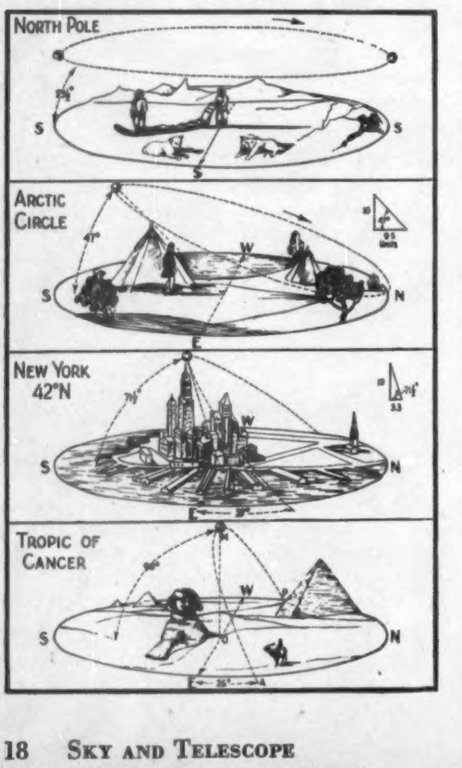
By Percy W. Witherell

NUMBER OF DAYS FROM SUMMER SOLSTICE TO HIGHEST NORMAL DAILY TEMPERATURE

## "Summer" Solstice

NOW that our interest in the southern areas of the earth is stimulated by the presence of our military forces below the equator, it may be of value to consider some of the differences in the seasons of the two hemispheres.

June 21st is called by us the summer solstice (from *sol-stitium*, the sun stands), to indicate that the sun has reached its highest *declination* above the equator. For a few days it appears at the same altitude, and we enjoy the longest days of the year (over 15 hours). The local mean times of sunrise and sunset are constant for several days at this period, because the decrease of the equation of time (difference between true and mean solar time) offsets the actual daily change.




The geography of our youth explained that the earth's axis is inclined 23½ degrees to the plane of the ecliptic and remains pointed to the celestial north pole as the earth revolves around the sun; that the illuminated half of the earth includes both poles at the vernal and autumnal equinoxes on March 21st and September 21st, so that the days and nights are equal; that at the summer solstice on June 21st the north pole is exposed to the sun and the south pole is in darkness; that at the winter solstice on December 21st the north pole is in shadow and the south pole is in sun.

A beam of light from the sun striking the earth perpendicularly covers a smaller space, and so is hotter per unit of area; the earth is heated by the sun during the long hours of daylight. In consequence, in the summer the earth becomes hotter and hotter each succeeding day, until the absorption and radiation of heat are equal and the average temperature reaches its maximum. The interval between the summer solstice and maximum average temperature varies from 10 days in Texas, to 40 days in Boston (August 1st), to 100 days at San Francisco. These differences are due to local conditions and are graphically shown in the accompanying chart by the U. S. Weather Bureau.

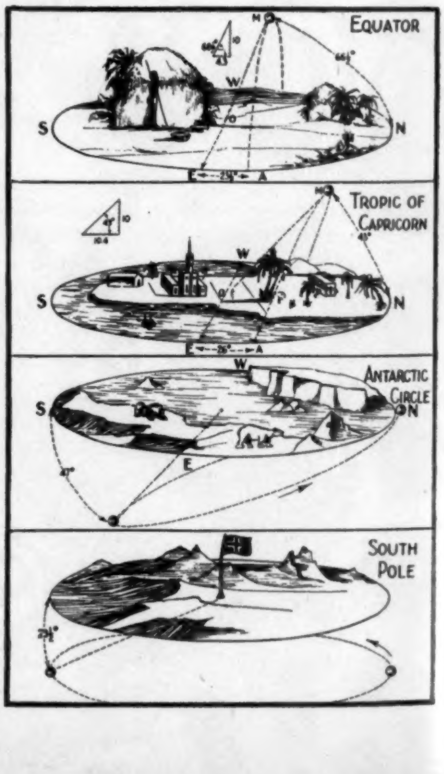
At the winter solstice the above conditions are reversed, and the coldest days of winter are reached at Boston in February, with variations for other locations as extensive, though not of the same degree, as noted for those of summer.

These conditions apply to the northern hemisphere. In the southern zones everything is reversed, so that winter occurs when we have summer, and there they enjoy summer flowers during our winter.

Because the earth's orbit is an ellipse and the sun is located at one of the foci, the earth's distance to the sun is less in the southern summer, which occurs at perihelion (nearest), than in the northern summer, which occurs at aphelion (remotest), so that summer is hotter in the southern hemisphere than in the northern. The winter conditions are the opposite of the above, so that the southern winter is colder than the northern. Although the southern summer temperatures are hotter, the season is seven days shorter than the northern, because the earth moves more rapidly in that part of its orbit: the total heat received in corresponding seasons is about equal in the two hemispheres.

In contrast to the above conditions in the temperate zones, at the equator day and night are always equal and there are no seasons of varied heat and cold. The wet and dry seasons of the tropics are the result of currents in the air and the oceans. Near the Arctic Circle, the long daily exposure to the summer sun explains the comparatively warm, but short summer. At the pole, where more heat is received from the sun in 24 June hours than at the equator for the same period, only the presence of the ice prevents very warm summer weather.

However, if you wish a change in the climate, in about 10,000 years the northern summer will be shorter and hotter than the southern.




Extremes of weather, of length of day, of daily path and position of the sun, are found as we pass from pole to pole at the time of the "summer" solstice. At the north pole, the sun shines continually and high enough to give great heat; at the Tropic of Cancer, it stands overhead at noon. Within the Antarctic Circle, the sun fails to rise. Diagrams, copyright, A. K. Lobeck.

# Amateur Astronomers

## Chicago Regional Astronomical Convention (Amateur)

OWING to restrictions on travel by motor cars and to the postponement of the Fourth National Convention of Amateur Astronomers, which was to have been held in Detroit, the astronomical societies in the Chicago area (within 150 miles of Chicago) are planning to hold a Regional Convention in which the various groups will participate. The dates are Saturday and Sunday, June 13th and 14th.

The preliminary convention program has been announced by Dr. Frank Hancock, president of the Burnham Astronomical Society of Chicago. Dr. Hancock states that he hopes this meeting will be a means of establishing a permanent regional convention in the Chicago area for years to come. He is asking all societies in the area to participate in planning and attending the convention.

Other events are expected to be added to the following schedule, which gives the program as arranged up to May 10th:

**Saturday, June 13th**

*Place of Meeting:* Congress Hotel, Chicago

10 a.m. *Address of Welcome*, Frank Hancock, president, Burnham Astronomical Society

10:15 *My Hobby*, Carl H. Gamble, Sky Ridge Observatory

11:30 Lecture (subject to be announced)

12:30 Luncheon

2 p.m. *Changing Conceptions of the Universe*, Robert L. Price, sponsor, Joliet Astronomical Society

3:30 Leave Chicago for Lake Geneva

6:30 Dinner in Lake Geneva

8:00 Guests of Dr. Otto Struve at Yerkes Observatory

**Sunday, June 14th**

2 p.m. *Michelson—The Man Who Measured the Stars*, Clarence R. Smith, Aurora College

3:30 *The Folly of Astrology*, Rev. Daniel J. McHugh, C.M., De Paul University

4:00 Presentation of *Sky and Telescope*, William Callum, vice-president, Burnham Astronomical Society

It is hoped that a large number of people will be able to attend the Regional Convention, in spite of transportation difficulties and war activities. All persons interested in astronomy, whether or not members of societies, are cordially invited to attend. Information may be obtained from the Burnham Astronomical Society, Congress Hotel, Congress and Michigan, or from William Callum, 1435 Winona, Chicago.

### "ANY ONE WHO CAN SEE CAN BE AN AMATEUR ASTRONOMER"

THESE words appear on the outside of an 8-page flyer which describes the history and activities, and gives the constitution and membership of the Yakima Amateur Astronomers, Yakima, Wash. Other amateur groups may well follow this example of a way to attract new members and to place their activities on a permanent and well-organized basis. Included in the flyer are short paragraphs under the headings: History, Purpose, Annual Dues, Monthly Open Meetings, Anniversary Banquet, Annual Picnic, Observation Nights, *The Observer*, Popular Astronomy Class, Telescope Making Division, Outside Lecturers, Publicity.

*The Observer* is the official publication of the Yakima Amateur Astronomers; it is a 4-page mimeographed monthly bulletin, and contains information and announcements of local and general interest. In a recent circular to other amateur societies, Edward J. Newman, editor of *The Observer*, suggests an exchange of his publication with those of other groups. He offers to send copies of *The Observer* to anyone who pays the postage (1½c an issue)—address him at Box 991, Yakima.

### Letter to the Editor

I should like to make a correction with regard to the letter in *Sky and Telescope*, May, 1942, page 18, which announced our decision to withdraw our invitation to hold the Fourth National Convention in Detroit, until better times return.

It is a source of much regret to find that we unintentionally misrepresented the reasons for being unable to include a visit to the McMath-Hulbert Observatory of the University of Michigan in our proposed program.

The actual reason, communicated by telephone, was that it would probably not be possible to allow a lot of visitors to the Observatory as pressure of work would probably not permit of this.

We should be grateful if you would print our sincere apology.

MARGARET BACK, secretary
Detroit Astronomical Society

### NEW YORK AMATEURS VISIT SPROUL OBSERVATORY

ONE of the most successful outings of the year took place on Saturday, April 25th, when about 40 members of the Amateur Astronomers Association visited Sproul Observatory of Swarthmore College, Swarthmore, Pa., on the invitation of Director Peter van de Kamp.

Prof. John H. Pitman and Dr. Leonard Barcus of the observatory staff met the amateurs on arrival and acted as hosts. The afternoon was spent in visits to the Edward Martin Biological Laboratory, one of the newer buildings of the college, and to the Physics Building, where experiments in optics and electronics were in progress.

After a pleasantly informal dinner in the College Dining Hall, everyone was invited to the observatory, which houses the astronomy lecture halls and work rooms as well as the 24-inch refracting telescope. Here a blink microscope was seen in operation, as were also measuring machines set with double-star plates made with the large refractor, which is particularly effective in this work because of its long focal length of 36 feet.

At Sproul, errors of measurement due to differences in the sizes of the double-star images are eliminated by using, in front of the objective, coarse gratings whose bars are spaced to give first-order spectra which are three or four magnitudes smaller than the central image. A grating is selected in each particular case which will give spectra of the bright component approximately equal to the direct image of the faint companion. (For a complete description of this method, see the article by Dr. K. AA. Strand in The SKY, May, 1941.)

The twilight hours were spent inspecting the large telescope and in taking several "peeks" through it. After dark, Prof. Pitman supervised the visitors in actual photographic practice at the 12-inch refractor, while Dr. Barcus operated a 5-inch for visual observation. Both of these latter telescopes are in the excellently equipped students' observatory.

Motion pictures in color were taken during the day for incorporation in the A.A.A.'s documentary film of its activities. All members of the society who made the trip are grateful for the hospitality of the staff of Sproul Observatory.

The main building of Sproul Observatory, showing the dome which houses the 24-inch refractor. Photo by K. AA. Strand.

# BOOKS AND THE SKY

## WEATHER AND THE OCEAN OF AIR

WILLIAM HOLMES WENSTROM. Houghton, Mifflin & Co., Boston, 1942. 484 pages. $4.50.

THIS book is written expressly for the general reader and the amateur meteorologist. It describes the atmosphere and its structure as a whole, and discusses the principal phenomena of the weather and climate of the globe. Not only does it treat the methods and instruments by which the technical meteorologist explores the atmosphere throughout its whole depth, the procedures by which he represents and analyzes current weather conditions on synoptic charts and diagrams, and prepares weather forecasts, but it also includes chapters on instrumental equipment, weather observations and weather forecasts (from local observations) that may be made by the amateur. Modern air-mass and frontal analysis is given prominence in the discussion of weather phenomena and forecasting.

The author was well qualified to prepare a book of this character through his long and responsible experience as a meteorological officer in the Army; and the book appears to be suitable for its intended purpose. It is entirely descriptive, written in a non-technical and interesting style, and includes many graphic accounts of personal experiences. The description of meteorological conditions in the troposphere and stratosphere, for example, with which the book opens, is accomplished largely through accounts of substratosphere and stratosphere flights in which the author took part.

Many interesting special topics are included, among which may be mentioned: the descriptions of some of the more spectacular weather phenomena—"black blizzards," ice storms, hurricanes, floods, and gales; the importance of weather conditions and forecasts to agriculture, forestry, aviation, military operations, and a wide range of industries; and a view into the future, indicating possible developments in instruments and technique (such as the Goddard rocket) that may lead to further advances in the science and practice of meteorology.

Several direct contacts with astronomy occur. The ultimate cause of all weather is the radiant energy received from the sun, and the particular way in which it is distributed over the earth. One chapter of the book is devoted to the sun, its radiation, and the immediate effects produced by the earth; and another chapter briefly discusses the somewhat controversial subject of the relation of conditions on the sun—sunspots, faculae, and associated variations in solar radiation—to weather and other atmospheric phenomena. Again, in attempting to determine conditions in the very high atmosphere beyond the reach of direct observation at present, the means employed include observations of twilight and of meteors.

In writing the book, the author sought criticism from many distinguished specialists in an effort to achieve accuracy. A few minor slips have been overlooked; and the simplification of explanations has here and there resulted in technical inaccuracies or insufficiencies, but in general the exposition is satisfactory for popular purposes.

However, the reviewer cannot agree with the author's answer to the often-proposed question on pages 427-428: How cold is twice as cold as zero? This question is among those most frequently received by the Weather Bureau, and the reply we give is as follows:

"This and similar questions which are quite frequently asked cannot be definitely answered, because the physical significance of the words that are involved makes these questions meaningless. Temperature is a conventional specification of a thermal condition. It does not express a *quantity* of anything. Furthermore, it specifies the condition with respect to heat, not with respect to cold. Cold is merely absence of heat, and has no reality in itself. Heat is energy and is the thing that is physically real.

"There is an absolute zero of temperature about 459° below zero on the Fahrenheit scale, at which there is complete absence of all heat, and temperatures measured from this point are called absolute temperatures; but there is no scale of cold. We might, if we wished, take the ratio of the absolute temperature at 10 degrees to the absolute temperature at zero degrees, and speak of this ratio as the number of times the temperature at 10 degrees is warmer than the temperature at zero degrees; but such a procedure would be without any real significance, and these terms are not used in scientific language.

"When used in everyday conversation, expressions of relative heat and cold probably refer to relative comfort or discomfort; but the state of one's feelings depends on many other factors in addition to the temperature, such as humidity, wind velocity, kind of clothing, sunshine, state of health, and so on."

EDGAR W. WOOLARD
U. S. Weather Bureau

# ASTRONOMICAL ANECDOTES

## "A BUDGET OF PARADOXES"

BACK in 1916, according to the issues of *Nature* through which I looked some months ago, there was quite a stir in England concerning the attitude of government toward scientists. Some of us may feel during the present war that our specialized abilities are not apparently as much in demand as we might wish, but the situation in England in 1916 was even more acute. Above the initials G.B.M., there is this somewhat prophetic statement:

"England's contempt for science, against which all who know have been protesting for a generation, will, if not amended, bring her down in sorrow to the ground, whatever the issue of the present war, which will be followed by one of much greater intensity, for which the weapons will be forged, not by hands, or machines, but by brains."

I wonder if he meant a literal war, or only an economic one?

The above appeared in a review of a new edition of Augustus De Morgan's *A Budget of Paradoxes,* a delightful potpourri if there ever was one. Those who know the book I am sure will not mind having some of the items recalled, and those who are not yet acquainted with it may have their appetites whetted, if I borrow a little of the book.

Observers of variable stars regularly report their observations with the Julian date, instead of the ordinary calendar date. This Julian day idea was suggested in 1582 by Joseph Scaliger, and the name comes from that of the father of the inventor. Joseph Scaliger was one of the great host who tried to "square the circle"—to evaluate exactly the ratio between the circumference and the diameter of a circle. Says De Morgan:

"There is no question about Scaliger's quadrature being wrong, in the eyes of geometers at least. . . . It made the circle less than its inscribed dodecagon, which is, of course, equivalent to asserting that a straight line is not always the shortest distance between two points. It was Scaliger himself who showed it, boasted of it, and declared it to be a 'noble paradox' that a theorem false in geometry is true in arithmetic; a thing, he says with great triumph, not noticed by Archimedes himself! He says in so many words that the periphery of the dodecagon is greater than that of the circle; and that the more sides there are to the inscribed figure, the more does it exceed the circle in which it is."

In a review of a tract concerning "A new method of discovering the longitude," De Morgan alludes to Dean Swift and his "prediction" of the satellites of Mars. This tract has to do with setting up stations in the Atlantic to fire off bombs at regular intervals, and an observer, by timing the interval between the flash and the sound, would be able to determine his distance from such a station. Concerning it, John Arbuthnot, mathematician, physician, and wit, wrote on July 17, 1714, to Dean Swift:

"Whiston has at last published his project of the longitude; the most ridiculous thing that ever was thought on. But a pox on him! he has spoiled one of my papers of Scriblerus, which was a proposition for the longitude not very unlike his, to this purpose; that since there was no pole for east and west, that all the princes of Europe should join and build two prodigious poles, upon high mountains, with a vast lighthouse to serve as a polestar. . . ." This was, of course, only fun on Arbuthnot's part; the scheme of Whiston was seriously put forth, with Ditton as his collaborator. The former was Newton's successor as Lucasian professor of mathematics at Cambridge, and the latter was, on Newton's recommendation, head of a responsible mathematical school in London. How could they have thus gone astray?

But De Morgan goes on to say that "Arbuthnot, I think, here and elsewhere, reveals himself as the calculator who kept Swift right in his proportions in the matter of the Lilliputians, Brobdingnagians, etc. Swift was very ignorant about things connected with number. He writes to Stella that he has discovered that leap-year comes every four years, and that all his life he had thought it came every three years. Did he begin with the mistake of Caesar's priests? Whether or no, when I find the person who did not understand leap-year inventing satellites of Mars in correct accordance with Kepler's third law, I feel sure he must have had help."

Concerning "The principles of the Philosophy of the Expansive and Contractive Forces," by Robert Greene (1727), De Morgan quotes the historian, Sanderson, in a letter to William Jones (in one of whose works, published in 1706, the symbol $\pi$ was first used to designate the ratio between circumference and diameter of the circle): "The gentleman has been reputed mad for these two years last past, but never gave the world such ample testimony of it before." It is Greene who is one of the sources of the story of Newton and the apple, and De Morgan says that Greene got it from Martin Folkes, a president of the Royal Society, and a friend of Newton. Folkes probably got it from Newton's niece, Mrs. Conduitt, to whom Voltaire attributed the story. Concerning the story, De Morgan says this:

"The story is pleasant and possible: its only defect is that various writings, well known to Newton, a very *learned* mathematician, had given more suggestion than a whole sack of apples could have done, if they had tumbled on that mighty head all at once. And Pemberton, speaking from Newton himself, says nothing more than that the idea of the moon being retained by the same force which causes the fall of bodies struck him for the first time while meditating in a garden. . . . Kepler's suggestion of gravitation with the inverse distance, and Bouillaud's proposed substitution of the inverse square of the distance, are things which Newton knew better than his modern readers. I discovered two anagrams on his name, which are quite conclusive: the notion of gravitation was *not new;* but Newton *went on.*"

R.K.M.

### NEW BOOKS RECEIVED

THE HIGH-SCHOOL SCIENCE LIBRARY FOR 1940-1941, *Hanor A. Webb.* 1941, *reprinted from Peabody Journal of Education, George Peabody College, Nashville, Tenn.* 15 pp. 15 cents.

A selected list of recent science books from juvenile to college freshman level is classified under 30 headings, gives publisher's name, price, and a few words of description on each book. The compiler's suggestions for purchasing books with budgets of from $10 to $200 and over make an interesting and valuable addition to the pamphlet for the teacher and librarian.

ENJOYMENT OF SCIENCE, *Jonathan Norton Leonard.* 1942, *Doubleday, Doran.* 327 pp. $2.50.

In an entertaining and sound book on science as avocation, the author discusses a number of sciences, particularly with regard to the amateur's viewpoint. Breezy and good bibliographies are included for each science.

STAR MAPS FOR BEGINNERS, *I. M. Levitt and R. K. Marshall.* 1942, *the authors, The Franklin Institute, Philadelphia, Pa.* 33 pp. 50 cents.

A series of 12 monthly star charts, with descriptions of constellations, some introductory material, and tables for locating the naked-eye planets through 1947.

### ANSWERS TO DO YOU KNOW?

(*Questions on page* 17)

I. 1, c; 2, d; 3, b; 4, a or c; 5, d; 6, b; 7, c; 8, b; 9, c; 10, b.

II. 1. Ceres is not a major planet.
2. Pyrrho is not a satellite of Jupiter.
3. Huygens is not a constellation.
4. Lyra is not a star.
5. Balliol is not an astronomer.
6. Campbell is not an observatory.
7. Copernican is not a type of telescope.
8. A manometer is not an astronomical instrument.
9. Gamma is not a unit of distance.
10. A light-year is not a kind of year.
11. Augustus is not a lunar crater.
12. Roy is not the name of a famous comet.
13. Kepler is not a contemporary astronomer.
14. 266,000,000 miles is not the distance from the sun of a principal planet.
15. Roche's limit is not concerned with light.

# GLEANINGS FOR A. T. M.s

EDITED BY EARLE B. BROWN

## Objective-Grating Plates

MOST amateur telescope makers have heeded the words of the wise in choosing suitable thicknesses for their telescope mirrors. But occasionally there comes a need for doing precision optical work on disks too thin to support themselves properly. Large Schmidt plates are often 60 to one in diameter-thickness ratio. Working them is attended with considerable difficulty apart from the aspherical surface required. The Warner & Swasey correcting plate is about 70 to one, as will also be the Harvard 60-inch plate. If in the future large correcting plates are achromatized by combination of crown and flint disks, flexure difficulties will prove still more important.

Here at Harvard, we are engaged in producing two 26-inch plates of spectacle crown, nearly one inch thick, polished and figured to plane parallelism. These plates are to be covered by R. W. Wood with mosaic transmission gratings for use with the Harvard and Cleveland Schmidt cameras. The tolerances run about one wave on surface quality, 10 waves on parallelism and curvature. It is intended, however, that the plates be within one wave length of flatness on each side.

There are two ways of looking at the problem of thin disks. One is to support the disk by firm contact, and, in the final stages of polishing, by optical contact on another prepared disk capable of holding its own shape to within the tolerance. The second is to support the thin disk on a flexible pad as uniformly as possible, and to work the plate in all possible positions. Most correcting plates for Schmidt cameras have been made with the aid of such flexible support.

The solid support has the trouble that it is a little on the ideal side. One has difficulty obtaining a sufficiently smooth surface for such support, as well as removing dust particles and air wedges that may produce some horrible result. The flexible support, on the other hand, presents the difficulty that the presence of any small prismatic wedge in the glass plate will cause greater sagging in one meridian than in another. Consequently, astigmatism is introduced into the plate and must be figured out in the end. Such figuring frequently results in loss of a perfect figure of revolution and, in consequence, loss of smoothness and precision.

Harvard possesses a grinding machine recently constructed by Frank Noyes, president of the Boston A.T.M. This machine is capable of making surfaces up to 40 inches in diameter. Mr. Noyes is also doing the work on the large plates. Probably A.T.M. enthusiasts will be interested in reading an account of the methods used so far, and the scheme for the final work:

A 26-inch iron table weighing about 315 pounds forms the turntable, support, and grinding surface for the thin plates. This iron table was cast, and heat-treated to prevent warping; it is over four inches thick and ribbed. After heat-treatment it was machined to approximate flatness and then ground flat with carborundum. As a check on flatness during the grinding, three glass straightedges, 26 inches long, one inch thick, and four inches wide, were made up by grinding one on the other in flat-making routine until the edges checked on one another in pairs. Such a straightedge laid across the iron table can show, with suitable illumination, departures from flatness of the order of 0.0001 inches. Grinding, always a slow process with iron on iron, is done with half-sized faceted iron tools heavily weighted.

The glass plates so far have been ground to flatness, and to parallelism as indicated by an ordinary micrometer. This parallelism in the finer stages of grinding will be measured by a 0.0001-inch dial indicator, good for such purposes to half a wave length, far within the tolerance. Obtaining parallelism when such tools are available is an easy and even pleasant process.

In the final stages of grinding with emery, when straightedges no longer can serve as adequate checks on flatness, the iron table will be brought to sufficient gloss to test for flatness by interference. During the very final stages of fine-grinding, glass will be ground on glass to avoid nasty scratches often given by iron tools. When sufficiently perfect surfaces are achieved through the use of #303½ emery, the iron table will be covered with a thin layer of some slightly flexible material, such as felt, as support for the glass during face-up polishing. Testing will be both by a small test flat when the plate is supported on its table, and by transmission with the Foucault test in conjunction with a 24-inch paraboloidal mirror in a testing tunnel. Testing will be carried out at the center of curvature. The double transmission and a factor of 1.5 in focal length between this mirror and the Schmidt for which the plate is intended provide a six-fold magnification of any error in the surface.

Although the later stages of the methods described here are merely planned, they have worked very well on plates up to 12 inches whose final precision has been one quarter wave per surface. Perhaps later, after the large (26-inch) plates are finished, we can report on our further experiences.

JAMES G. BAKER
Harvard College Observatory



## SKY-GAZERS EXCHANGE

*Classified advertisements accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge, Mass.*

## SOME ASTRONOMICAL METHODS

(*Continued from page 10*)

one or more secondary stars. (See "Observer's Page.") These secondary stars are not planets, but stars in their own right. Yet they undoubtedly obey the same laws which Newton and Kepler found to hold true in the solar system. There is this difference—in the solar system the planets are so small compared to the sun that they all seem to move around it as an almost "stationary" master, whereas in double-star systems the masses are more nearly equal, and the motion appears to be more noticeably one of mutual rotation around a common center of gravity.

If we know the distance from the earth to the stars of a binary system, we can compute the actual distance between them, using our triangle again. From this knowledge, and a detailed study of their mutual motion to determine the period of revolution, we can calculate their masses. (The expression used is: $m_1 + m_2 = a^3/p^3P^2$, where $m_1$ and $m_2$ are the masses of the components in terms of the sun; a is the apparent semi-major axis of the orbit; p is the parallax; and P is the period in years.) From well-known elements for certain double stars, such masses have been computed. From these, it has become evident that stars are extraordinarily alike in one characteristic — they all have about the same mass.

Some stars are millions of times brighter than others. Some stars are billions of times larger than others. But all are included in a mass range from 1/10 to 100 times the sun, and the great majority are nearly equal to the sun in the amount of matter they contain. Generally, the brightest are the most massive. Therefore, the process whereby we compute the masses of double stars whose distances are known may also be worked backward. We can estimate the masses of a binary pair, and by combining our knowledge of brightness and mass, determine the distance of the system from the earth. Naturally this method, known as *dynamical parallax,* depends to an extent upon our original estimate of the masses, but a pretty fair determination of distance results in many cases.

I said before that even with the largest telescope now in existence, the stars appear as mere points of light. How is it possible, then, to measure their sizes? The most modern method of what might be considered direct measurement is by use of the interferometer, an instrument which extends the power of the telescope, so to speak. Using the interferometer we still cannot see the star as a real disk, but we can learn how big a telescope would be necessary to show it to us that way. This tells us, then, how large a star appears to be. If, in addition, we know its distance, our triangle can be applied to determine its diameter, and therefrom, its size.

But the interferometer can only be used on the very largest stars. For the great majority of them, older, more indirect methods must be relied upon. Most of these are essentially ways of determining the temperatures of the stars, and the simplest is just to look at the star's color. We all use the expressions "red hot" and "white hot" when we have seen things really turn red and then white as they get very hot. If need be, we can almost guess the temperature of a piece of hot metal by observing its color. The same method applies to the stars. Blue and white stars are the hottest; orange and red stars are relatively cool, at least on their surfaces.

But it is the surface temperature which determines how much light a star will give off from its surface. Therefore, we might expect that of two stars, one red, one blue, the latter would shine many times brighter if it were the same size as the former. Of course, size can compensate, and there are "giant" red stars which glow comparatively feebly, yet equal or exceed hot blue stars in total brilliance, simply because they have such extensive surfaces. Consequently, once a star's temperature and absolute magnitude are known, its size can be estimated. Stars are known which, if placed at the center of the solar system, would fill the entire space out to Mars or Jupiter; others are so small that many of them would fit inside our earth.

In this respect, the contributions of the spectroscope are very important, as in so many other phases of astronomy. (See *Sky and Telescope,* May, 1942, for two articles discussing modern spectroscopy.)

We have seen how the astronomer uses light, gravitation, and mathematics to obtain his end. Step by step, utilizing every means that comes to hand, he is steadily uncovering the mysteries of space. Perhaps, some day, the final result will be a clear and definite picture of the universe, and of man's place among the stars.

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### LIST OF DOUBLE STARS—R. A. 12h to 16h

***This list, the first in a series which will cover the entire sky, furnishes amateurs with complete observing data on the bright, resolvable binaries. See the "Observer's Page" for an article on the visual observation of double stars.***

The columns are: star designation; right ascension, declination (1950); photometric magnitudes; "Aitken" visual magnitudes; spectral classes; separation; position angle.

*A* and *B* are the brighter (primary) star and fainter star, respectively. Where available, the photometric magnitudes are given to two places; magnitudes in parentheses are estimated or uncertain. "Aitken" magnitudes are from visual observations and often differ greatly from the photometric figures, therefore the former are useful chiefly to indicate the relative magnitude difference between the components.

The data for this table is compiled from the Boss *General Catalogue;* Aitken's *Double Star Catalogue;* and Innes' *Southern Double Stars.*

| | | *R. A.* | | *Dec.* | | *Photometric mag.* | | | *Aitken* | *Spectra* | | *Sep.* | *P.A.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h* | *m* | ° | ′ | *A+B* | *A* | *B* | *mag.* | *A* | *B* | | |
| Bootes | τ | 13 | 44.9 | +17 | 42 | 4.51 | — | — | 4.8–11.4 | F5 | — | 7″.0 | 360° |
| | κ | 14 | 11.7 | +52 | 1 | (4.4) | 4.60 | 6.61 | 5.1—7.2 | A5 | A5 | 13″.2 | 238° |
| | ι | 14 | 14.4 | +51 | 36 | 4.78 | — | — | 4.9—7.5 | A5 | A2 | 38″.4 | 33° |
| | Σ1835 | 14 | 20.9 | + 8 | 40 | (4.9) | 5.11 | 6.64 | 5.5—6.8 | A0 | F2 | 6″.4 | 190° |
| | π | 14 | 38.4 | +16 | 38 | (4.5) | 4.94 | 5.81 | 4.9—6.0 | A0 | A0 | 6″.0 | 105° |
| | ε | 14 | 42.8 | +27 | 17 | 2.70 | (2.8) | 5.12 | 3.0—6.3 | K0 | A3n | (3″.0) | 333° |
| | 39 | 14 | 48.0 | +48 | 56 | 5.64 | — | — | 5.8—6.5 | F5 | F1 | 3″.4 | 45° |
| | ξ | 14 | 49.1 | +19 | 18 | 4.64 | 4.80 | 6.82 | 4.7—6.6 | G5 | K4 | 3″.6 | 30° |
| | 44 | 15 | 2.2 | +47 | 51 | 4.86 | — | — | 5.2—6.1 | G0 | — | 3″.4 | 245° |
| Camelopardalis | | | | | | | | | | | | | |
| | 32 H | 12 | 48.6 | +83 | 41 | (4.8) | 5.28 | 5.81 | 4.9—5.4 | A2 | A0 | 21″.5 | 326° |
| Canes | 2 | 12 | 13.6 | +40 | 56 | 5.80 | — | — | 5.7—8.0 | K5 | — | 11″.5 | 260° |
| Venatici | α | 12 | 53.7 | +38 | 35 | (2.8) | 2.90 | 5.39 | 3.2—5.7 | A0p | A0p | 19″.7 | 228° |
| | 25 | 13 | 35.2 | +36 | 33 | 4.92 | — | — | 5.7—7.6 | F0 | — | 1″.5 | 115° |
| Centaurus | k | 13 | 48.9 | —32 | 45 | (4.4) | — | — | 4.7—5.9 | B5 | — | (8″) | 107° |
| Coma | 2 | 12 | 1.7 | +21 | 44 | 5.77 | — | — | 6.0—7.5 | F0 | F2 | 2″.9 | 236° |
| Berenices | 24 | 12 | 32.6 | +18 | 39 | (5.0) | 5.18 | 6.72 | 4.7—6.2 | K0 | A3 | 20″.1 | 271° |
| Corona Borealis | | | | | | | | | | | | | |
| | ζ | 15 | 37.5 | +36 | 48 | (4.7) | 5.07 | 6.00 | 4.1—5.0 | B8 | B8 | 6″.3 | 304° |
| Corvus | δ | 12 | 27.3 | —16 | 14 | 3.11 | — | — | 3.0—7.5 | A0 | — | 24″.2 | 212° |
| Hydra | f | 13 | 34.0 | —26 | 14 | 5.49 | — | — | 5.2—7.1 | A2 | A | 10″.9 | 192° |
| | 54 | 14 | 43.1 | —25 | 14 | 5.21 | — | — | 5.2—7.1 | F5 | — | 8″.9 | 128° |
| Libra *Piazzi* | 212 | 14 | 54.5 | —21 | 11 | (5.7) | 5.76 | 8.87 | 7.0—8.0 | K5 | K5 | 19″.9 | 299° |
| | Σ1962 | 15 | 36.0 | — 8 | 38 | (5.8) | 6.54 | 6.61 | 6.3—6.4 | F8 | F8 | 11″.8 | 189° |
| Lupus | ξ | 15 | 53.7 | —33 | 49 | (4.8) | 5.37 | 5.73 | 5.6—6.2 | A0 | A0 | 10″.6 | 48° |
| | η | 15 | 56.8 | —38 | 15 | (3.6) | 3.64 | 7.69 | — | B3 | — | 14″.7 | 21° |
| Scorpius | ξ | 16 | 1.6 | —11 | 14 | 4.16 | 4.77 | 5.07 | 4.9—5.2 | F8 | F8 | 7″.4 | 60° |
| Serpens | δ | 15 | 32.4 | +10 | 42 | (3.8) | 4.23 | 5.16 | 3.0—4.0 | F0 | F0 | 3″.8 | 183° |
| Ursa Major | ζ | 13 | 21.9 | +55 | 11 | (2.2) | 2.40 | 3.96 | 2.1—4.2 | A2p | A2 | 14″.5 | 150° |
| Virgo | γ | 12 | 39.1 | — 1 | 11 | 2.91 | 3.65 | 3.68 | 3.0—3.0 | F0 | F0 | 5″.7 | 315° |
| | θ | 13 | 7.4 | — 5 | 16 | 4.44 | — | — | 4.0—9.0 | A0 | — | 7″.2 | 343° |
| | φ | 14 | 25.6 | — 2 | 0 | 4.97 | — | — | 5.2—9.7 | K0 | — | 4″.7 | 110° |

# OBSERVER'S PAGE

By Jesse A. Fitzpatrick

**All times mentioned on the Observer's Page are Eastern War Time.**

## Visual Double-Star Observations

*(See list on preceding page)*

A carefully planned system for the observation of double stars will prove of inestimable value to the amateur who is interested in finding how his telescope may assist him in learning star positions, separations, and color classifications. The beginner is too frequently satisfied with such well-known pairs as Mizar, Albireo, and Beta Scorpii, but he does derive much pleasure from observing their various combinations of color and from knowing his telescope can make two stars out of one.

Visual double stars are of two types. The first is the "optical double," in which the components are in no way related to each other and are really at enormously different distances from us. They appear close together merely because they are in the same direction, or nearly so. The second type, "binary systems," are actually double stars, having a physical bond in the force of gravity between the components.

Every star has an apparent motion perpendicular to our line of sight which is called its *proper motion*. This is very slight, amounting at most to only a few seconds of arc every 10 years, but measurable by accurately mounted telescopes. The proper motions are more or less at random, and it would be a rare chance that any two stars that appear close together would travel in the same direction and with the same speed unless they had a physical connection. Therefore, it is by proper motions that astronomers are able to differentiate between optical doubles and binary systems. I suggest re-reading the article by the late Dr. Heber D. Curtis in The SKY, April, 1941, concerning the work of Dr. Robert G. Aitken on visual double stars, especially that portion in the middle column of page 5 wherein is suggested a working limit for the separation of double stars.

This article will deal primarily with the binary systems, but in our lists, optical doubles will receive notice whenever advisable.

The layman often asks, "Are there any more solar systems in the universe?" and the answer must be, "We do not know and probably never will until some instrument is invented which is far more powerful than our modern telescopes." But in a binary double star we have something that resembles the solar system, in that there are two bodies, relatively close together, revolving around a common center of gravity in a comparatively short period, and in accordance with the same three laws of Kepler that apply to planetary orbits.

Usually, the linear separation of the two stars in a visual double is measured, not in light-years, but in astronomical units. (One A. U. is 93 million miles.) The orbit of Pluto has a radius of about 40 A. U. and its period is 248 years; Castor B has an orbit of three or four times this size and a period of 380 years. However, Castor C is about 1,000 A. U. from the A-B pair, and is known to be part of the system by its common proper motion and parallax.

Although thousands of double stars are listed in Dr. Aitken's catalogue, the periods of revolution are known in comparatively few cases. However, the U. S. Naval Observatory takes the orbital motion into account in computing the apparent positions of the following eight stars: $\eta$ Cassiopeiae; Sirius; Castor; Procyon; $\alpha$ Centauri; $\sigma$ Coronae Borealis; $\zeta$ Herculis; and 70 Ophiuchi. In addition, data are furnished in the *American Ephemeris and Nautical Almanac* each year for the stars $\gamma$ Virginis and i Bootis to enable computation of the position of each component with reference to the mean place of the binary system. This information will be useful in predicting the occultation time of $\gamma$ Virginis next December 3rd.

During the coming months we propose to print occasional lists of the double stars to be found in definite parts of the sky, generally those portions in good observing position before midnight. In this issue all the important doubles north of 40° south declination and from 12h to 16h, right ascension, are listed. The positions are those of the epoch 1950—slight variations from the true present positions of the stars will not hinder their location in the telescope. For faint doubles, use a nearby bright star as a guide and a low magnifying power so as to produce the largest field. At first, your search may require considerable patience, but it will be rewarded by not only finding the double star, but by your gaining useful knowledge of star positions and distances.

Of course, faint stars can be found more easily with permanently mounted telescopes equipped with setting circles, but these are by no means essential. However, good star charts, such as Norton's, Schurig's, or Webb's, are very necessary, and an *American Ephemeris* of fairly recent date is also indispensable. The editions of 1940 and earlier are preferable since they contain the places of over 900 stars, whereas in 1941 and later the list is reduced to about 200.

Next month I shall discuss further details of visual double-star observations, especially with reference to separation, position angle, and spectral classes.

### PHASES OF THE MOON

| | |
|---|---|
| Last quarter | June 5, 5:26 p.m. |
| New moon | June 13, 5:02 p.m. |
| First quarter | June 21, 4:44 p.m. |
| Full moon | June 28, 8:09 a.m. |

### OMEGA CENTAURI

Probably the finest naked-eye globular cluster is Omega ($\omega$) Centauri. In the southern skies it stands out clearly as a small white cloud, slightly smaller than the moon, and is found at the intersection of lines drawn through $\beta$ and $\epsilon$ Centauri and $\delta$ and $\gamma$ Centauri. I was agreeably surprised one perfectly clear night a year ago to pick it up in my telescope at my home near New York City, although it was only 2°.5 above the horizon. On June 1st it is on the meridian at 10 p.m. War Time. Those living in our southern states should see it very plainly. During the many years that I observed in the tropics, I became very well acquainted with this cluster, and found with a magnification of 50 the appearance was that of a perfectly circular nebulous mass. It required a magnification of 240 in my 4½-inch refractor to resolve the cluster into individual stars.

### THE PLANETS IN JUNE

*Venus*, in Pisces, Aries, and Taurus, is still a bright object in the morning sky, rising about two hours before the sun.

*Mars* will pass through the Praesepe cluster in Cancer on June 24th.

*Neptune* begins its progressive motion on June 8th. See chart in the February issue.

All other planets are too near the sun for observation.

*The sun* arrives at 6 hours right ascension on June 21st at 9:17 p.m., and summer begins in the northern hemisphere of the earth.

### THEOPHILUS

On June 18th, while we are timing the occultations of 19 and R Leonis and the conjunction of 18 Leonis, there will be a fine opportunity to observe the effect of the moon's libration in bringing into view the crater Theophilus. As stated in my article in the January issue, this crater is in excellent position when the moon is five days old, if there is no libration. When the libration is negative, this is the case eight hours earlier, and at positive libration, eight hours later.

Maximum negative libration occurs on June 20th, less than two days after our occultation observations. At 10 o'clock on the night of the 18th, the moon will be five days and five hours old, or about 10 or 12 hours older than the time for Theophilus to be in good observing position. So we may expect the crater to be placed well west of the terminator with too much sunlight in the interior to give the necessary contrast between light and shadow.

Theophilus is without doubt second only to Copernicus among the more beautiful formations on the moon, but librations and the moon's early setting when five days old make it difficult to become well acquainted with this magnificent object.

## OCCULTATIONS—JUNE, 1942

Local station—lat. 40° 48'.6, long. 4h 55.8m west.

| *Date* | *Mag.* | *Name* | *Immersion* | *P.** | *Emersion* | *P.** |
|---|---|---|---|---|---|---|
| June 1 | 6.5 | 130 B Sagittarii | 3:26.5 a.m. | 86° | 4:43.2 a.m. | 265° |
| 4 | 6.1 | 151 B Capricorni | 5:20.6 a.m. | 79° | 6:40.4 a.m. | 237° |
| 18 | 6.4 | 19 Leonis | 10:02.2 p.m. | 75° | 10:52.7 p.m. | 322° |
| 18 | 6 to 7 | R Leonis | 10:06.5 p.m. | 105° | 11:05.6 p.m. | 293° |
| 20 | 6.4 | 80 Leonis | 10:44.4 p.m. | 174° | 11:16 p.m. | 231° |
| 24 | 6.5 | 623 B Virginis | 0:15.6 a.m. | 137° | 1:14.1 a.m. | 260° |
| 24 | 5.5 | 95 Virginis | 1:22.1 a.m. | 106° | 2:22.2 a.m. | 286° |
| 25 | 5.5 | 49 Librae | 11:47.8 p.m. | 140° | 0:47.4 a.m.-26 | 246° |
| 26 | 6.4 | 29 Ophiuchi | 11:16 p.m. | 173° | 11:39.2 p.m. | 208° |
| 30 | 5.5 | 29 Capricorni | 10:55.3 p.m. | 126° | 11:40.8 p.m. | 215° |

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

Immediately preceding the occultations of 19 and R Leonis on June 18th, 18 Leonis (magnitude 5.9) will be in conjunction with the moon. This will happen at 10:00.8 p.m., at which moment the star will be north of the moon's edge by a distance equal to nine per cent of the moon's diameter. The position angle of the moon's axis, 21 degrees, will cause the conjunction to be on a line midway between the craters Strabo and Gartner. The two occultations and the conjunction, occurring within a period of six minutes, will be very interesting. In the Chicago area, the three stars will be occulted.

Unfortunately, we will be unable to see the occultation of $\eta$ Virginis (magnitude 4.0) on June 21st at our New York City station, happening as it does just as the moon sets. It is only on rare occasions that we are privileged to observe such a bright star disappear behind the moon. However, observers in the middle west will be more fortunate, and witness an occultation if the weather is clear. At the standard station, lat +40° 0', long. 91° 0' west, which is near Quincy, Ill., the immersion will occur at 11:40.2 p.m. (C.W.T.), June 21st, and the emersion at 0:28.6 a.m. on the 22nd.

### THE ECLIPTIC CHART

**at the right is drawn with the ecliptic as its central line, instead of the celestial equator. Perpendicular to this are lines marking celestial longitude. The positions of the sun, moon, and inner planets are shown for the beginning, middle, and end of the month. The outer planets do not change materially from the positions shown during that time. Computations for plotting the planets are by Sidney Scheuer.**

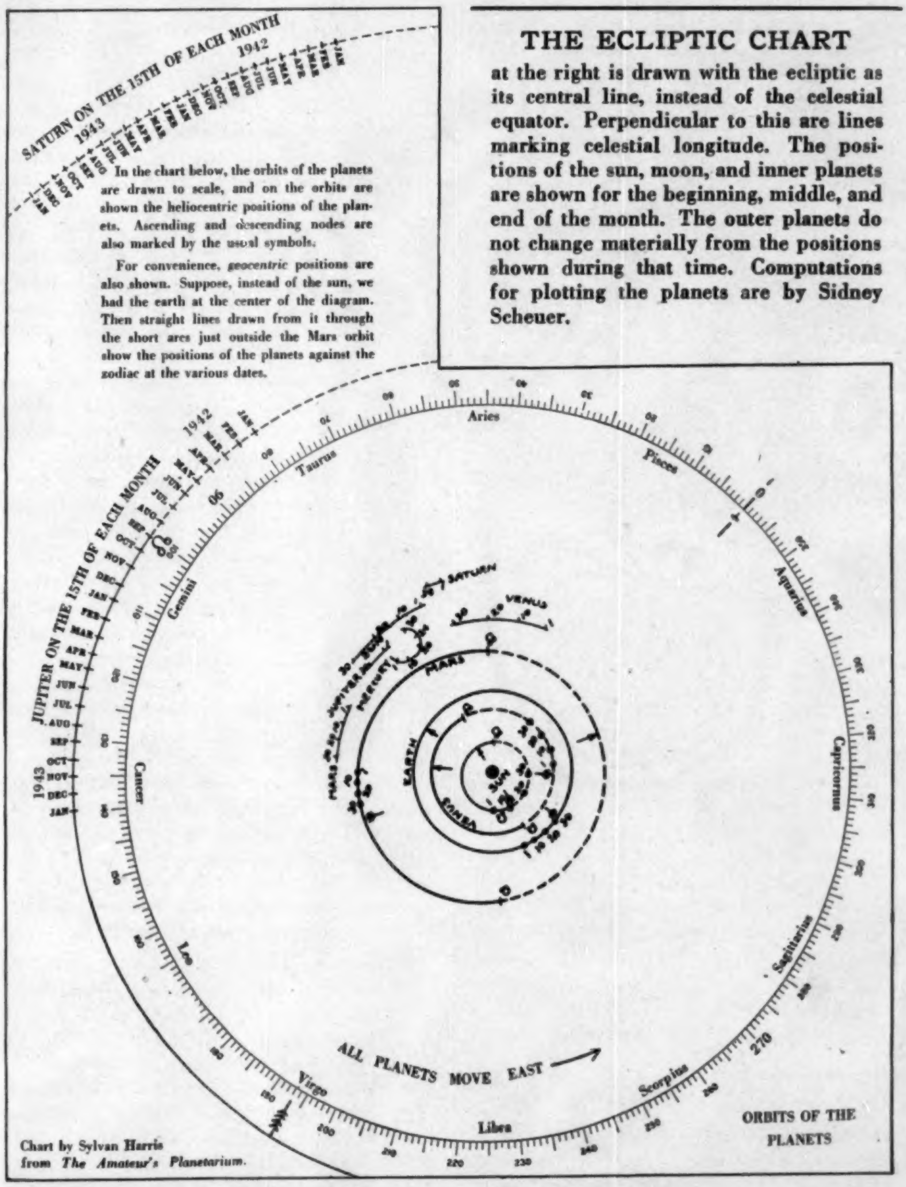
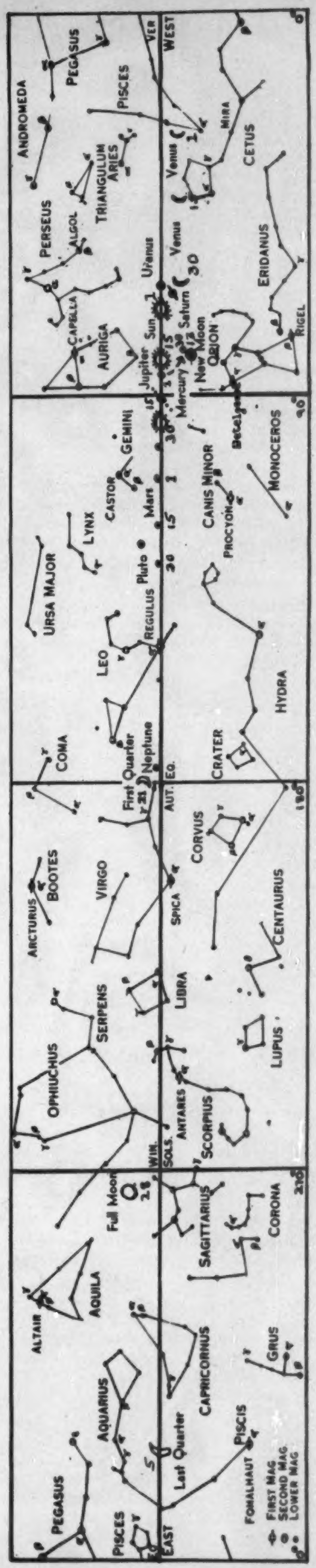



Chart by Sylvan Harris from *The Amateur's Planetarium.*




THE APPARENT POSITIONS IN THE HEAVENS OF THE SUN, MOON, AND PLANETS.

# The Starry Heavens in June

### By Leland S. Copeland

THE winter arch of the Milky Way has just disappeared in the west as June opens, and the grander summer branch is rising above the northeastern and southeastern horizons, from Cassiopeia in the far north to Lupus in the south. But not till late in the month will the Milky Way be high enough to delight the sky hunter.

In May and early June the north galactic pole in Coma Berenices is near our zenith. If at that time we gaze upward, we shall be looking out from our stellar homeland into the great depths. In May we are reminded least of the greatness of our own galaxy. We might expect that in November, when the south galactic pole in Sculptor crosses the meridian, the Milky Way would be hard to find, but at that season it arches so high in the north that it is still an ornament of night.

Included in the June sky are two leading hour lines, the equinoctial and the solstitial colures. The first passes between $\gamma$ and $\delta$ of the Big Dipper bowl, runs just east of Denebola ($\beta$ Leonis), and goes through the autumnal equinox, west of Porrima ($\gamma$ Virginis). Ninety degrees farther east, the solstitial colure drops between Hercules and Lyra, descends east of the head of Ophiuchus, and glides through the winter solstice, west of the little Milk Dipper in Sagittarius.

Ruling the mid-June meridian of 10 p.m., War Time, is Bootes with splendid Arcturus. An extension of the curve of the handle of the Big Dipper, concave toward the west, leads through Arcturus to Spica in Virgo.

Ophiuchus with Serpens occupies a huge part of the southeast. Head to head with him shines Hercules, upside down. Lyra and Cygnus follow. Aquila, due east, has just risen, and the Scorpion, showpiece of summer, towers above the southern horizon.

In the west the Bear and the Lion are nosing toward their setting. They are followed by Canes Venatici, Coma Berenices, and Virgo.

## WHERE GALAXIES SWARM

BEHIND the stars of Virgo lies the richest cluster of galaxies that can be seen through amateur telescopes. This nest is the nearest of the supergalaxies, seven million light-years distant. It dominates northern Virgo and scatters across into southern Coma Berenices.

When Clemenceau, Tiger of France, described the stars as "beacons in a shoreless sea unfathomed and unfathomable," his words could have been applied even more aptly to the galaxies. But galactic beacons, though many of them have a "star power" of a billion or more, are so unimaginably remote that when their light reaches unaided human eyes it usually is too feeble to register. In amateur telescopes these marvels appear wee and ghostly.

Galaxies are at once nothing and everything—nothing to the eye, everything to the instructed mind.

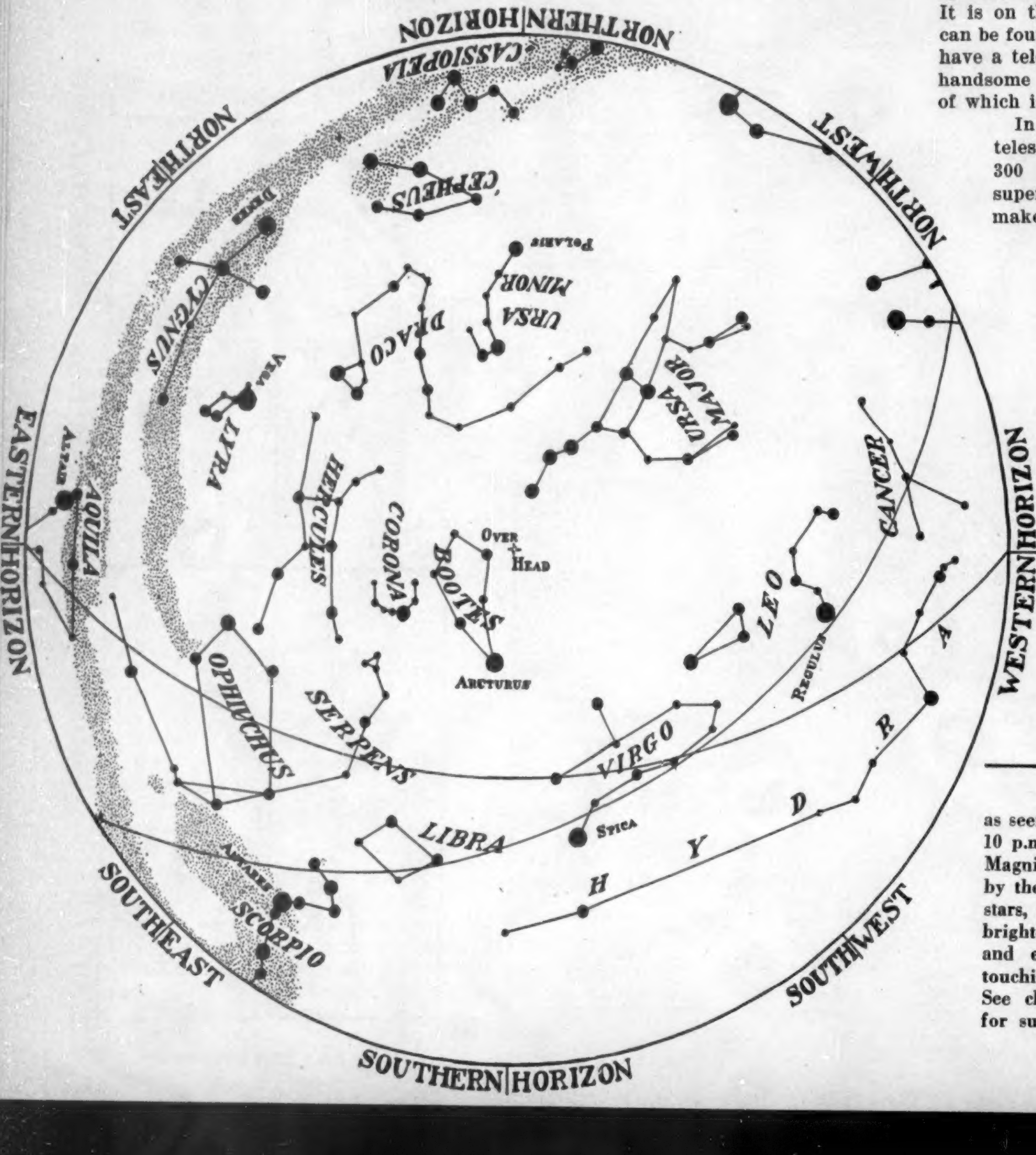
Virgo is the second largest constellation. Its preceding part is a great *Y*, with Spica at the bottom, Porrima at the crotch, and Vindemiatrix ($\epsilon$) at the top of the eastern arm. Its bent western arm appears under Denebola of the Lion. In eastern Virgo four stars form a zigzag line that extends from $\theta$ (between Spica and Porrima) toward $\beta$ Librae.

Porrima is a member of a "Gamma group" of double stars, which includes the Gammas of Andromeda, Aries, Cetus, Crux, Delphinus, Leo, and Lepus. Most of these are notable sights in common telescopes. (See pages 23 and 24.)

The Sombrero, one of the brightest spirals, lies between Porrima and $\delta$ Corvi. It is on the Virgo-Corvus boundary and can be found at 12h 37m, —11° 21′. If you have a telescope, be sure to look for this handsome deep-sky wonder, a photograph of which is on the back cover.

In a single evening an amateur telescope will disclose 1/10 of the 300 members of the Coma-Virgo supergalaxy. Sky tourists should make Vindemiatrix their headquarters and travel westward on various declination lines. Here the "sights" are so close together that amateurs have less difficulty in finding these objects than in identifying them.

A story retold by Aratus says that Virgo represents the goddess of justice. In the golden age Justice dwelt on earth and took a kindly interest in mortals. As their life became decadent in the silver age, she reproved them and foretold impending wars and woes. At last, in the bronze era, she lost hope and fled to heaven, where she appears as the constellation of the Maiden.




### THE STARS FOR JUNE

as seen from mid-northern latitudes at 10 p.m., June 7th; 9 p.m., June 23rd. Magnitudes of the stars are indicated by the sizes of the disks marking the stars, and the names of some of the brighter stars appear. The ecliptic and equator are shown, the latter touching the east-west horizon points. See chart on the "Observer's Page" for sun, moon, and planet positions.

# HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for traveling amateurs who may wish to visit other groups.

| City | Organization | Date | Hour | Season | Meeting Place | Communicate with |
|---|---|---|---|---|---|---|
| BOSTON | Bond Ast. Club | 1st Thu. | 8:15 p.m. | Oct.-June | Harvard Observatory | Homer D. Ricker, Harvard Observatory |
| " | A.T.M.s of Boston | 2nd Thu. | 8:15 p.m. | Sept.-June | Harvard Observatory | F. I. Noyes, 340 Warren St., Brockton, Mass. |
| BROOKLYN, N. Y. | Astr. Dept., B'klyn Inst. | Round Table 3rd Thu. | 8:00 p.m. | Oct.-April | Brooklyn Institute | William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473 |
| BUFFALO | A.T.M.s & Observers | 1st & 3rd Fri. | 8:00 p.m. | Oct.-June | Museum of Science | J. J. Davis, Museum of Science |
| CHATTANOOGA | Barnard A. S. | 4th Fri. | 7:30 p.m. | All year | Chattanooga Obs. | C. T. Jones, 1220 James Bldg., *CHat.* 6-8341 |
| CHICAGO | Burnham A. S. | 2nd & 4th Tue. | 8:00 p.m. | Sept.-June | Congress Hotel | Wm. Callum, 1435 Winona Ave. |
| CLEVELAND | Cleveland A. S. | Fri. | 8:00 p.m. | Sept.-June | Warner & Swasey Obs. | Mrs. Royce Parkin, The Cleveland Club |
| DAYTONA BEACH, FLA. | D. B. Stargazers | Alt. Mon. | 8:00 p.m. | Nov.-June | 500 S. Ridgewood Ave. | Rolland E. Stevens, 500 S. Ridgewood |
| DETROIT | Detroit A. S | 2nd Sun. | 3:00 p.m. | Sept.-June | Wayne U., Rm. 187 | E. R. Phelps, Wayne University |
| " | Northwest A. A. S. | 1st & 3rd Tue. | 8:00 p.m. | Sept.-June | Redford High Sch. | A. J. Walrath, 14024 Archdale Ave. |
| DULUTH, MINN. | Duluth Ast. Club | 1st & 3rd Sat. | 8:00 p.m. | All year | Darling Observatory | W. S. Telford, 126 N. 33rd Ave. E. |
| FT. WORTH | Tex. Observers | No reg. meetings | ........ | | | Oscar E. Monnig, 1010 Morningside Dr. |
| GADSDEN, ALA. | Ala. A. A. | 1st Thu. | 7:30 p.m. | All year | Ala. Power Auditorium | Brent L. Harrell, 1176 *W* or 55 |
| INDIANAPOLIS | Indiana A. A. | 1st Sun. | 2:00 p.m. | All year | Central Library Audit. | E. W. Johnson, 808 Peoples Bank Bldg. |
| JOLIET, ILL. | Joliet A. S. | Alt. Tue. | 8:00 p.m. | Oct.-May | Jol. Mus. & Art Gallery | Monica L. Price, 403 Second Ave. |
| LOS ANGELES | L. A. A. S. | 2nd Thu. | 8:15 p.m. | ...... | 2606 W. 8th St. | Charles Ross, 2606 W. 8th St. |
| LOUISVILLE, KY. | L'ville A. S. | 3rd Tue. | 8:00 p.m. | Sept.-May | Women's Bldg., Univ. of Louisville | Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157 |
| MADISON, WIS. | Mad. A. S. | 2nd Wed. | 8:00 p.m. | All year | Washburn Observatory | C. M. Huffer, Univ. of Wisconsin |
| MILWAUKEE | Milw. A. S. | 1st Thu. | 8:00 p.m. | Oct.-May | Marquette U., Eng. Col. | E. A. Halbach, *Hopkins* 4748 |
| MOLINE, ILL. | Pop. Ast. Club | 2nd Tue. | 7:30 p.m. | All year | Sky Ridge Observatory | Carl H. Gamble, Route 1 |
| NEW HAVEN | New Haven A. A. S. | 1st Sat. | 8:00 p.m. | Sept.-June | Yale Observatory | F. R. Burnham, 820 Townsend Ave., 4-2618 |
| NEW YORK | A. A. A. | 1st & 3rd Wed. | 8:15 p.m. | Oct.-May | Amer. Mus. Nat. Hist. | G. V. Plachy, Hayden Plan., *EN.* 2-8500 |
| " " | Junior Ast. Club | Alt. Sat. | 8:00 p.m. | Oct.-May | Amer. Mus. Nat. Hist. | J. B. Rothschild, Hayden Plan., *EN.* 2-8500 |
| NORWALK, CONN. | Norwalk Ast. Soc. | Last Fri. | 8:00 p.m. | Sept.-June | Private houses | Mrs. A. Hamilton, 4 Union Pk., 6-4297 |
| OAKLAND, CAL. | Eastbay A. A. | 1st Sat. | 8:00 p.m. | Sept.-June | Chabot Observatory | Miss H. E. Neall, 6557 Whitney St. |
| PHILADELPHIA | A.A. of F.I. | 3rd Fri. | 8:00 p.m. | All year | The Franklin Institute | Edwin F. Bailey, *Rit.* 3050 |
| " | Rittenhouse A. S. | 2nd Fri. | 8:00 p.m. | Oct.-May | The Franklin Institute | A. C. Schock, *Rit.* 3050 |
| PITTSBURGH | A. A. A. of P'burgh | 2nd Fri. | 8:00 p.m. | Sept.-June | Buhl Planetarium | F. M. Garland, 1006 Davis Ave., N.S. |
| PONTIAC, MICH. | Pontiac A. A. A. | 2nd Mon. | 8:00 p.m. | All year | Cranbrook Inst. of Sci. | J. P. Coder, 2675 Voorheis Rd., 2-9419 |
| PORTLAND, ME. | A. S. of Maine | 2nd Fri. | 8:00 p.m. | All year | Private Homes | H. M. Harris, 27 Victory Ave., S. Portland |
| PROVIDENCE, R. I. | Skyscrapers | 1st Wed. | 8:00 p.m. | All year | Wilson Hall, Brown U. | Ladd Obs., Brown U., *GA.* 1633 |
| READING, PA. | Reading-Berks A. C. | 2nd Thu. | 8:00 p.m. | Sept.-June | Albright College | Mrs. F. P. Babb, 2708 Filbert Ave. |
| RENO, NEV. | A. S. of Nev. | 4th Wed. | ........ | All year | Univ. of Nevada | G. B. Blair, University of Nevada |
| ROCHESTER, N. Y. | Roch. Ast. Club | Alt. Fri. | 8:00 p.m. | Oct.-May | Eastman Bldg., Univ. of Rochester | P. W. Stevens, 1179 Lake Ave., *Glenwood* 5233-R |
| SAN ANTONIO | San Ant. A. A. | 3rd Mon. | 8:00 p.m. | All year | Le Villela | R. B. Poage, 807 Hammond Ave. |
| SCHENECTADY | S'tady Ast. Club | 3rd Mon. | 8:00 p.m. | All year | Observatory site | C. H. Chapman, 216 Glen Ave., Scotia |
| SOUTH BEND, IND. | St. Joseph Val. Ast. | Last Tue. | 8:00 p.m. | All year | 928 Oak St. | Fannie Mae Chupp, 224 Seebirt Pl. |
| STAMFORD, CONN. | Stamford Ast. Soc. | 4th Wed. | 8:00 p.m. | All year | Stamford Museum | Thomas Page, Stamford Mus., 300 Main St. |
| TACOMA, WASH. | Tacoma A. A. | 1st Mon. | ........ | All year | Coll. of Puget Sound | Geo. Croston, *Gar.* 4124 |
| WASHINGTON, D. C. | Nat'l. Cap. A. A. A. | 1st Sat. | 8:00 p.m. | Oct.-June | U. S. Nat'l. Museum | Stephen Nagy, 104 C St., N.E., *Linc.* 9487-J |
| WICHITA, KANS. | Wichita A. S. | 2nd Tue. | 8:00 p.m. | All year | East High Sch., Rm. 214 | S. S. Whitehead, 2322 E. Douglas, 33148 |
| YAKIMA, WASH. | Yak. Am. Astr'mers | 2nd Tue. | 7:30 p.m. | All year | Y.M.C.A. Auditorium | J. L. Thompson, 4 S. 10 Ave., 21455 |

*Sky and Telescope* is official publication of many of these societies.

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# PLANETARIUM NOTES

*Sky and Telescope* is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

## ★ THE BUHL PLANETARIUM presents *in June,* ABC OF ASTRONOMY.

Designed for all who wish an all-around picture of the great universe about us, the Buhl Planetarium's June sky show includes everything from meteors to galaxies. Here visitors have a graphic survey of the cosmos telescoped into one short hour through the magic of lenses and mirrors. We find which of the beautiful spectacles of the heavens take place, like the northern lights, in the oceans of air above, and which, like eclipses of sun and moon, occur in the vast oceans of empty space beyond. We get acquainted with the planet Mars, seeing it, spinning in space like a cosmic top, as though we were but a few thousand miles distant. A bird's-eye view of the solar system shows us where the earth fits into the scheme of things. Then, leaving the little family of the sun, we examine those other suns—the stars—and the fantastic "island universes" which lie so unbelievably far away. In "ABC of Astronomy" is offered a simple, visual explanation of the celestial phenomena everyone sees in the sky but which still are puzzling and mysterious to many.

## ★ THE HAYDEN PLANETARIUM presents *in July,* THE SUN.

This month we shall consider the sun, that great storehouse of energy. The story of the sun is never complete without a review of the way we have learned its size, shape, distance, and composition. The Hayden Planetarium will again use its specially constructed heliostat, and on clear days bring into the dome and project on the sky a large solar image that shows sunspots, if any are present. At night and when the sky is overcast, a photograph is used as a substitute.

*In August,* ECLIPSES, ANCIENT AND MODERN.

On the night of August 26th there will be a striking eclipse of the moon that you can see if the weather is clear. However, fair weather or foul, the whole selection of eclipses of the sun and moon can be seen in the Hayden Planetarium every day during August. Partial, total, and annular eclipses of the sun; partial and total eclipses of the moon, appulses, and so on, will be discussed, in conjunction with special projection equipment, movies and stills.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Fridays............................3, 8, and 9 p.m.
Saturdays ............................2, 3, 8, and 9 p.m.
Sundays and Holidays............................3, 4, 8, and 9 p.m.

★ STAFF—*Director,* Arthur L. Draper; *Lecturer,* Nicholas E. Wagman; *Business Manager,* Frank S. McGary; *Public Relations,* John J. Grove; *Curator of Exhibits,* Fitz-Hugh Marshall, Jr.

★ SCHEDULE HAYDEN PLANETARIUM

**Mondays through Fridays......................2, 3:30, and 8:30 p.m.**
**Saturdays......................11 a.m., 2, 3, 4, 5, and 8:30 p.m.**
**Sundays—Mutual Network Broadcast—Coast-to-Coast....9:30-10:00 a.m.**
**Sundays and Holidays......................2, 3, 4, 5, and 8:30 p.m.**

★ STAFF—*Honorary Curator,* Clyde Fisher; *Curator,* William H. Barton, Jr.; *Assistant Curators,* Marian Lockwood, Robert R. Coles; *Staff Assistant,* Fred Raiser; *Lecturers,* Alden E. Moore, Asa Tenney, John Ball, Jr.

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